THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 29. Thursday, May 1, 1924. No. 402.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of
THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

Contents.

	PAGE
The Possibilities of Cast Iron Welding	351
The Institute of British Foundrymen	352, 365
Correspondence	352
Contracts Open	352
Pig-Iron: Its Characteristics and Uses	353
Catalogues Received	358
Fluxes and Slags in Metal Melting and Working	359
Heat Treatment of Semi-Steel	364
A New Zealand Exhibition	364
Obituary	366
Liquid Steel for Light Castings	367
Personal	368
Iron and Steel Markets	370
Trade Talk	372
Company News	372
Gazette	372

Forthcoming Events.

MAY 2.

Institute of Metals (Swansea Local Section):—General meeting at Swansea.

JUNE 4 to 6.

Institute of British Foundrymen.—Annual Convention at Newcastle.

JUNE 4-5.

British Empire Mining and Metallurgical Conference.—At Wembley.

JUNE 19 to 28.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1
Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.
Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.
Sheffield: R. Village, Jaggers Lane, Hathersage, near Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.
Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
Coventry: J. M. Meston, 37, Melville Road.
West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.
Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.

Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

The Possibilities of Cast Iron Welding.

The successful welding of cast iron as a regular commercial process has only been accomplished during the past few years, but there are now a number of people who are willing to undertake the welding of cast-iron parts, and several ironfounders and engineering works have installed equipment for repairing castings in the factory. Hitherto this work has been principally applied to repairs, especially where the question of delivery time of a new casting is important.

In a recent lecture to the British Acetylene and Welding Association, the Director of the Cast Iron Research Association rightly emphasised the suitability of oxy-acetylene welding for cast iron, since material is cast into the weld and hence may be made similar in character to the base metal. Why should the method not be applied to fabricated structures and building up of parts?

The answer is that progress achieved to date has been made in spite of, rather than because of, existing metallurgical knowledge and skill. The conditions which require to be observed in cast-iron welding have been found by welders through a process of trial and error, and much experimental work has been done on parts which are not afterwards submitted to any severe stresses.

At the same meeting the excellent suggestion was made that the two industries should join hands for the purpose of conducting an investigation on the conditions to be observed in the welding of cast iron, the limitations to such welding, and the choice of proper fluxes. If the Cast Iron Research Association would undertake to conduct such a research, financially assisted by the interested welding firms, it is believed that the conclusions would be adopted readily by the industry and put into practice quickly. This would facilitate considerably the development of cast-iron welding and would render unnecessary the almost impossible guarantees which are now asked of welders by people for whom the repair is to be undertaken.

The Cast Iron Research Association could arrange for the conduct of an investigation planned by a joint committee of the two bodies. The whole of the material and equipment required could be supplied by the interested parties with little actual expenditure of funds beyond the salary of a suitable investigator. It is known that welding research is being conducted very vigorously in the United States through the American Welding Society. The formation in this country of the Institution of Welding Engineers is further assisting to create an atmosphere favourable to the recognition of welding as an important process.

Ironfounders know that in a real sense every piece of cast iron is unique. Its heterogeneous character can only be appreciated by those who have produced it for years. At the present time the only satisfactory way of welding an important piece of work is to carry out a chemical and microscopic examination of the casting and prepare a suitable welding rod, with due regard to welding losses and fluxing considerations, so that the material deposited in the weld shall have chemical and physical characteristics similar to that of the base metal. Pre-heating to 500 deg. C. is desirable, followed after welding by slow heating to a point above the pearlitic change point, and subsequent slow cooling. We would urge the acetylene industry, in its own interests, to make the fullest use of metallurgical knowledge and experience in undertaking cast-iron welding, as in this way many difficulties which the welder only finds by experience can be anticipated and guarded against, and failures will not be attributed to the process or to "unweldable" iron.

The Institute of British Foundrymen.

Annual Convention at Newcastle-upon-Tyne, June 4, 5 and 6, 1924.

The details of the Newcastle Conference have now been completed, and the following programme, together with a reply form, is being circularised to members:—

Tuesday, June 3.

Evening.—Seats at reduced prices may be obtained at either of the following picture halls if sufficient applications are received. There will be a continuous programme in each case:—(a) The Newcastle Picture House; (b) The Queen's Hall.

Wednesday, June 4.

9.30 a.m. prompt.—Conference opens in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road. Welcome by the Lord Mayor of Newcastle and the President of the Newcastle and Gateshead Chamber of Commerce.

10.30 a.m.—Ladies will visit places of interest in Newcastle.

12.30 p.m.—The ladies are invited by the Convention Committee to lunch at Tilley's Restaurant, and will be welcomed by the Lady Mayoress.

2 p.m.—Members and ladies are invited to visit one of the following works:—(c) The Redheugh Gas Works, Gateshead-on-Tyne; (d) The Wallsend Slipway & Engineering Company, Limited, Wallsend-on-Tyne; (e) C. A. Parsons & Company, Limited (Engineers), Heaton, Newcastle-on-Tyne; (f) "The Chronicle" Office, Newcastle-on-Tyne; (g) J. Dampney & Company (Paint Works), Gateshead-on-Tyne, and (h) A. S. Wilkin & Company, Limited, Cremona Toffee Works, Newcastle-on-Tyne (ladies only). All of these firms have kindly promised to provide tea.

6.30 p.m.—Banquet at the Grand Assembly Rooms for members and ladies. (Morning dress.) Tickets—single ticket, 7s. 6d.*; combined ticket (lady and gentleman), 12s.*

* These prices do not cover the total cost of the banquet, the balance being defrayed by the Convention Committee.

Thursday, June 5.

9.30 a.m.—Conference continues.

10.30 a.m.—Motor trip to the Coast for ladies, with lunch at Whitley Bay. By invitation of the Convention Committee.

3.30 p.m.—Garden Party at Jesmond Dene, by invitation of the Lord Mayor.

7.30 p.m.—Members and ladies are invited by the Convention Committee to attend the Theatre Royal, where "The Co-Optimists" (from Prince of Wales' Theatre, London) are appearing. Seats have been reserved in stalls and dress circle. (Morning dress.)

Friday, June 6.

9.30 a.m.—Members and ladies are invited to visit one of the following works:—(j) The Carville Electric Power Station, Wallsend-on-Tyne; (k) The North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne; (l) Smith, Patterson & Company, Limited, Pioneer Foundry, Blaydon-on-Tyne; (m) C. T. Maling & Sons, Ford Potteries, Newcastle-on-Tyne; (n) Sir W. G. Armstrong, Whitworth & Company, Limited, Close Works Foundry, Gateshead; (p) Sir W. G. Armstrong, Whitworth & Company, Limited, Naval Shipyard, Walker; (q) The Lemington Glass Works, Lemington-on-Tyne; (r) The Northern Counties Ice-making and Cold Stores Company, Limited, Newcastle-on-Tyne; and (s) Langdale's Chemical Manure Co., Ltd., Newcastle-on-Tyne.

1.30 p.m.—Lunch for members and ladies at the Grand Assembly Rooms, by invitation of the Convention Committee.

3 p.m.—Members and ladies have the choice of one of the following:—(t) Motor drive to Rothbury (back to Newcastle by about 9 p.m.), by invitation of Convention Committee; (u) Sail down the River, by invitation of the Tyne Improvement Commissioners (back to Newcastle by about 7 p.m.).

Hotel Accommodation.—The hotel accommodation is very limited, and members should reserve rooms as soon as possible. Messrs. Thos. Cook & Son, Northumberland Street, Newcastle-on-Tyne, will be pleased to help in obtaining accommodation, and members are recommended to apply to them in case of difficulty.

Souvenir Booklet and Badge.—A souvenir booklet, giving programme in detail, and a badge will be supplied to each member and lady attending the Convention.

Clubs.—The following Clubs will extend their hospitality to members of the Institute:—The Northern Conservative Club, the Newcastle Liberal Club, and the William Morris Club (Labour).

Conference Office.—An Office at the Literary and Philosophical Society, Westgate Road, will be open for issue of tickets, badges, booklets, etc., and for general information on Tuesday, June 3, from 4 p.m. till 8 p.m., and on Wednesday and Thursday, June 4 and 5, from 9 a.m. till 1 p.m.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Economy in Cupola Practice.

To the Editor of the Foundry Trade Journal.

Sir,—It is rather surprising to learn that there are German engineers now in this country advising those using a cupola on how to lessen the coke consumption.

This is a question which interests all in the foundry trade, but it is to be regretted that we should find it necessary to import information. There are many well-known experts on this question in England, and papers which have appeared in The Foundry Trade Journal should have proved that it was not necessary to go very far for advice.

A little inquiry in the right quarters might be helpful, and would help to brighten business at home instead of abroad.—Yours, etc.,

Druslyn, Bishops Road, Whitchurch, Glam. Ethel Rawden.

[Apart from the question of nationality, any help, from whatever source, which can help British foundries to lower the coke consumption in cupola furnaces will be welcome, as it will aid them to make cheaper castings, and so compete with more ease in the world's markets.—Ed.]

Contracts Open.

Toronto, May 13.—Cast-iron pipes, for the Board of Control, City of Toronto. The Department of Overseas Trade.

London, S.E., May 6.—Bearing plates for rails, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Santiago, May 30.—Steel rails and fishplates, for the Chilean Ministry of Railways, for supply to the Arica-La-Paz Railway. The Department of Overseas Trade.

Melbourne, May 21.—327 tons of mild steel plates and 120 tons of mild-steel angles and tees, for the Victorian Government Railways. The Department of Overseas Trade.

Santiago, May 26.—Stores, for the Signalling Department of the Chilean State Railways: Copper and galvanised-iron wire and cables; galvanised-iron anchors for posts, stays, insulator pins, cast-iron covers for cable boxes, padlocks, galvanised-iron piping, lead tubes; welding apparatus, handsaws, trucks, etc. The Department of Overseas Trade.

Messrs. Smeeton Wright Furnaces, Limited, of St. Stephen's House, Victoria Embankment, London, S.W.1, have sold a Schurrman cupola to Messrs. Crofts (Engineers), Limited, of Thornbury, Bradford. This furnace claims the suppression of the endothermic $CO_2 + C = 2CO$ reaction, and incorporates a regenerative system for the waste gases.

A remittance out of the proceeds of the sale by auction in Buenos Aires of the assets and business of the Argentine Iron & Steel Company has been sent to London for account of the debenture holders' claims and the costs of the receivership action. It is hoped that the amount received will, after payment of the costs and expenses of the action, suffice to repay the capital of the debentures in full and possibly some portion of the arrears of interest.

Pig-Iron: Its Characteristics and Uses.*

By H. Field, M.I.Brit.F.

The following Paper has neither been written as a treatise on pig and cast iron, nor as a thesis on microstructure and macrostructure, nor a defence or destruction of inherent properties, nor even yet as a critical comparison between the value of analysis and fracture but simply and solely because the word "iron" still conveys to many foundrymen only as much distinctive information as does the use of the word "stuff" when applied to that wide range of materials which the fair sex so deftly and effectively adapt to their adornment. To many who daily handle the ferrous metals, all which is not white as aluminium, or red as copper, is iron and iron only. Behind them lies another class to whom the use of the word may conjure up visions of steel, wrought iron, malleable iron or cast iron, but to the intelligent foundryman it presents a hundred possibilities and iron to him is anything but iron unless it is the one particular brand, fracture, analysis, strength and fluidity which he desires.

The object of this Paper, then, is to help any foundry worker who, daily seeking and perhaps handling tons of pig or cast iron, still lacks knowledge or imagination to understand why (over and above the reasons of trade competition) there are "brands" of iron, why one brand is preferred to another, why pig-iron should be carried the length and breadth of the country, and lastly why various castings around him in the foundry are

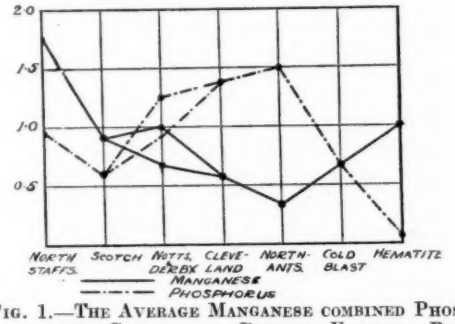


FIG. 1.—THE AVERAGE MANGANESE COMBINED PHOSPHORUS CONTENT OF BRITISH FOUNDRY PIG-IRONS.

cast from different mixtures. The "savants" present will please remember that this is an elementary Paper, and be tolerant accordingly.

In considering the location of various industries throughout the country, it is apparent that some have sprung up in a district because of local needs for their particular products, whilst the interests of others are vitally bound up with imports or exports. The scattered nature of the iron making industry is due to Nature's abundant but widespread provision of two essential raw materials—iron ore and coal. Wherever to-day there are blast furnaces, it may be taken for granted that *there* originally was found either one or the other of these, and in fact often both of them. Some of the ore fields are more or less exhausted—the South Staffordshire iron making district being an example. The direct use of coal no longer obtains, having given place to coke, the manufacture of which being scarcely so widespread as the original distribution of coal, hence we find in many cases to-day fuel being transported long distances for smelting purposes. Therefore there are a few instances where neither fuel nor ore are now found on the spot, and many more where only either one or the other remains. The former class are struggling for existence against a sealed doom, the latter are working under a heavy disability. It may be that in the future new centres will develop, *e.g.*, the mining of coal in Kent may enable ore to be imported from France.

The principal ore fields of the United Kingdom are now Cleveland, whose famous ironstone yields only about 30 per cent. iron; Scottish Blackband with a similar iron content, but, as its name denotes, high in organic matter: Northamptonshire and surrounding counties providing brown hematite with 45 per cent. iron; Cumberland and Forest of Dean, red hematites with a valuable iron content reaching to 65 per cent.; and Staffordshire, with a 35 per cent. clay-ironstone in the South, and a high manganese blackband in the North, both being in relatively small quantity. In addition to these, imported ores are more or less largely used, but not in the production of foundry irons, and no further mention of them is needed.

Value of Ores.

As will be seen later the amount of iron in an iron ore is not the only important feature any more than the actual amount of iron in pig-iron is a criterion of its value or properties. Although it is of first importance that the ore should contain sufficient iron to make its extraction profitable, there are nevertheless rich iron-bearing materials—such as iron sulphide or "Blue Billy"—in which the impurities are such, both in quality and quantity, as to render them useless for smelting purposes. It is therefore important to notice the high manganese in Staffordshire blackband and the gradual increase of phosphoric oxide in passing from hematite on to Scotch and Staffordshire ores, and then to Cleveland and Northamptonshire ores. It is also important to

TABLE I.—*Distribution of the Blast Furnaces of the United Kingdom.*

Area.	Sept. 30th, 1923.		
	Built.	In blast.	Foundry and forge iron.
Scotland	102	44	33
Derbyshire	43	23	23
Cleveland District ..	74	32	16
Northamptonshire	21	9	8
South-West Yorkshire ..	17	8	6
Notts, Leicester	8	5	5
North Staffs.	20	11	4
South Staffs.	30	10	3
Shropshire	6	2	2
Durham, Northumberland	40	14	—
South Wales, Monmouth ..	36	10	—
Lancashire	30	14	—
Lincolnshire	23	18	—
West Cumberland	30	11	—
North Wales	4	3	—
Gloucester, Somerset, Wiltshire	2	—	—
	486	214	100

bear in mind that although the combined moisture may be driven off from brown hematite and the organic matter from blackband, there is no method of removing phosphoric oxide from any iron ore.

Distribution of Blast Furnaces.

The blast furnaces of the United Kingdom are equally widespread, and their main distribution is shown from Table I compiled from the very useful sheet issued quarterly by THE FOUNDRY TRADE JOURNAL. A large amount of the iron made from these furnaces goes to the steelworks, and so is not important to the founder, practically the whole of the South Wales and Lancashire outputs being thus accounted for. As is well known, the chief foundry iron centres are Scotland, Cleveland, Derbyshire, Northamptonshire, and the lesser ones Lincolnshire, Notts and Leicester, North and South Staffs. Of minor importance are the Shropshire furnaces, whilst white hematite pig for malleable work comes from the North-East and North-West Coast. An experienced practical man knows that every one of the classes or "brands" mentioned has its valuable features, either in price or quality, and a survey of typical analyses would confirm his judgment. Of course, the districts shown are sub-divided into many works or groups of furnaces, e.g., Northamptonshire with Cransley,

* A Paper read before the Birmingham and East Midland Branches of the Institute of British Foundrymen.

Islip, Butlin, Lloyds, Kettering, Rixon; and Derbyshire with Stanton, Butterley, Clay Cross, Denby, Awsworth, Sheepbridge, and Staveley. One or other of these may be preferred by various users, but each field has nevertheless its broadly constant yet peculiar product.

The various "brands" named above vary widely both in analysis and in physical properties. Northamptonshire iron is weak, but very fluid and admirably suited for light and ornamental work; Cleveland and South Staffs common iron are a little higher up the scale; Notts and Derbyshire give an iron moderately strong and admirably suited for machinery work; Scotch iron is still stronger, but it is found that fluidity has given place to strength, in fact to such an extent that the Scotch makers of light castings use iron from Cleveland and even Northamptonshire in preference to their home product. Strength and fluidity are not commonly found in the same pig iron.

In addition to these wide classes there are on the market a number of "special" irons, often highly recommended for cylinder and other high-pressure work. Some of these are made by admixture of high-class ores, some by a refining process in open-hearth furnaces, and some by melting steel with pig iron in either cupola or open-hearth furnace. Examples of these are the South Staffs irons "Titan," "Capponfield," "1X.L.," etc. Again beyond these there are the cold-blast irons, such as Lowmoor and Lilleshall, which are renowned for a strength begotten by purity through the cold blast used. Table II shows details of modern South Staffordshire practice for which the author is indebted to an anonymous friend.

TABLE II.—*Raw, Natural and Finished Product of South Staffs. Pig Iron.*

South Staffs. Clay Ironstone.		South Staffs. Pig Iron.	Warm Blast.	Cold Blast.
FeO	45 to 50	Silicon	1.0	0.7
CO_2	30	Sulphur	0.10	0.12
SiO_2	10	Phosphorus ..	0.40	0.45
Al_2O_3	5	Manganese	0.65	0.80
P_2O_5	0.4	Total Carbon ..	3.3	3.0

These irons have one quality in common—high price—and considerable discretion is required in purchasing, for there are irons round about us which are being advertised as "Special" but which possess no virtues worthy of the name. It is very easy for the founder to grow into a habit of calling for special irons thinking that they will solve all his troubles, but this rarely happens.

The Movements of Constituent Elements.

The various elements which together make up the complex product known as pig iron are derived from the ore by reduction, or from the coke by absorption, during smelting in the blast furnace. Phosphorus is mainly derived from calcium phosphate in the ore, silicon and manganese from their respective oxides, sulphur mainly from the coke, and carbon wholly therefrom. The laws governing the transfer of these elements into the pig are not the same in every case. Only a small fraction of the silica in the ore is reduced to silicon, the proportion being greater in hot working furnaces; and only one-twentieth or thereabouts of the total sulphur passes from coke to iron. On the other hand, manganese passes almost entirely into the iron, the loss being greater with small percentages. Phosphorus, too, is transferred even more completely from ore to iron, the only exceptions to this rule being when the slag is excessively rich in ferrous oxide or when there is over 3 per cent. phosphorus in the ore. The former exception is an undesirable one, owing to the effect on furnace lining, and the latter is an unusual one, as very few ores contain over 1 per cent. phosphorus. It is unfortunate that so stern a law governs the reduction of phosphorus, for it would be greatly advantageous if low-phosphorus iron could be produced from phosphoric ores, and would raise considerably the value of much of British ore supply. The truth of this statement with regard to phosphorus is seen by a survey of the amount of this element in various Northamptonshire irons, when one is struck by the small variation found.

How Carbon Enters Pig-Iron.

With regard to carbon, this element is derived from the coke, not directly, but through the decomposition of carbon monoxide, and sometimes carbon dioxide, whereby carbon is deposited on the spongy iron and passes down into the hearth. There is little or no direct control over the amount of carbon in the final pig, although this is limited by the amount of other elements present, by furnace temperatures and by other conditions, such as size of ore, rate of descent, etc. Generally hot working increases carbon so that siliceous irons are higher in carbon than white or mottled irons, and cold-blast iron is low in carbon. Carbon is also usually higher in low-phosphorus irons, so that Northamptons are lower than hematites, the high carbon in the latter being a drawback to their use.

Virtues and Drawbacks of Hematite Iron.

Many foundrymen believe that hematite is the most valuable iron in the foundry where high-class castings are concerned. The only fact which can be adduced to support such a belief is that this iron is very low in phosphorus and sulphur—not only very low, but reliably low—and fairly high in manganese. It has no other virtues, however, and has this considerable drawback, that it is not made for the foundry but for the steel-maker, and *he* does not mind what the carbon is so long as sulphur and phosphorus are under 0.04 per cent.

It is furthermore believed that these furnace conditions influence not only the amount of carbon but also the structural or physical properties of the deposited graphite, which, if correct, would help to account for some of the apparent vagaries of irons of similar analysis.

TABLE III.—*Phosphorus-classification of Pig Irons.*

Non Phosphoric.	Medium Phosphorus.	High Phosphorus.
Hematites from East and West Coasts, Forest of Dean.	Scotch South Staffs. Specials: 1 X L Titan, etc.: Most cold blast iron Notts., Derby and Leicester, Lincolnshire.	Cleveland. South Staffs. Northampton-shire.

The differences noticeable amongst various brands of pig-iron are therefore due firstly to the use of different kinds of ore, and secondly to the diverse conditions obtaining within the furnace. These latter are again divisible into (*a*) variations within one furnace from time to time, this producing differences in one brand of pig, such as those already referred to under silicon and carbon—and (*b*) intentional variations in practice between one furnace and another producing known differences in the respective irons. In spite of all these variations arising from many causes, there may still remain some constant feature attached to every furnace, and it is only by becoming acquainted with this determining element that the foundryman can readily appreciate the relation between the various pig-irons of the country.

Owing to the uncertainty in the reduction of silicon and its wide variation in one furnace over even small intervals of time, it is impossible to classify the various iron-producing areas of the country according to silicon content in their product. Neither can carbon be adopted for this purpose, for it is even more beyond control. Classification can only be made by taking as a basis an element which varies but little over a long period, and it has been shown that phosphorus alone comes definitely under this category and manganese to a less extent. It therefore becomes customary to divide the furnaces according to the average phosphorus content of their iron, which is dependent upon the ore smelted, the whole of the phosphorus passing into the iron (Table III).

Characteristics of Pig-Irons.

Examined analytically the characteristics of the principal foundry irons are as follows:—

North Staffs.—This is the highest manganese iron in the country, and is combined with rather high phosphorus (0.9 to 1.2 per cent.).

Scotch.—Manganese fairly high and phosphorus low (0.6 per cent.).

Notts, Derby and Leicester. — Manganese medium (reaching to 1 per cent. in some cases); phosphorus medium (0.7 to 1.2 per cent.).

Cleveland.—Manganese lower (0.5 per cent.) and high phosphorus (1.3 per cent.).

Northampton.—Low manganese (0.3 per cent.) and high phosphorus (1.5 per cent.).

Cold Blast.—Low silicon and carbon; manganese and phosphorus low to medium; sulphur often high.

Hematite.—High carbon and manganese with very low phosphorus.

The matters so far considered have been those related to analysis, but these can only be of interest to the foundryman so long as they have any practical bearing upon his work. Speaking broadly, it may be confidently said that the physical properties of iron are related to, and dependent on, the chemical analysis, although there is much which at present analysis does not explain. The well-known characteristics of various brands of iron are due to the presence or absence of one or another of the elements usually associated therewith, and as has already been seen what these elements are, how they come to be in the iron, and how much they are likely to vary, one can now proceed to state for what property each element is responsible. On the basis of our general knowledge of the analyses from various districts, one can form a plan of the likely properties and so learn how to select a suitable district according to the properties required in the finished casting.

Influence of Phosphorus on Pig-Iron.

Phosphorus is not the most important element in iron but it is the most dependable, and it will therefore be well to first see for what it may be held responsible. Some workers have sought to show that this element has a direct effect on carbon condition, causing the latter to be retained in the combined form and so giving hardness. The author is working continuously with the very lightest of castings made in iron with 1.50 per cent. phosphorus, and after experiment and comparison with lower phosphorus irons, cannot agree that the higher phosphorus causes harder metal. It is, in fact, possible to make several thousands of tons per annum of light castings with 1.50 per cent. phosphorus, and to give almost universal satisfaction to the machinists, a record on which no comment is needed. Possibly with very low-silicon irons phosphorus heightens or appears to heighten the effect of this low silicon. Beyond the fact of its comparatively low price, high-phosphorus iron is used in these light castings because of its great fluidity and its expansion on solidification. Fluidity is an indispensable property for light work, whilst expansion on solidification is also very valuable, for it enables an iron to take and retain the delicate impressions of the mould, an important factor in small machine parts where a high degree of accuracy is demanded and in ornamental castings with intricate designs. Not only does phosphorus impart fluidity, but also increases the range of temperature through which the metal remains molten, a distinctly different characteristic. This property is observed particularly in making large castings, and since it is an effect directly opposite to that of a chill, it causes, or allows to be formed, hollow shrinkage cavities within the mass of metal. It has been said that phosphorus has little effect on hardness, and it is also true that it has small influence on tensile strength. In mixtures containing steel the author obtains regularly 16 and 17 tons per sq. in. tensile with up to 1.50 per cent. phosphorus, using principally Northampton irons, and cannot see any marked improvement when this element is reduced, others remaining constant. On transverse strength it admittedly has considerable effect, causing a lowering thereof, and this incidentally suggests that the transverse test is a better reflex of the iron than is the tensile.

Its most noticeable effect on mechanical properties is seen in the shock test or impact test where an iron with 1.50 per cent. phosphorus will give only half the value of a low-phosphorus iron. This effect is one which everyone who handles iron encounters.

These properties clearly explain the suitability of Cleveland or Northampton iron for light castings, but not for heavy work, and show why the Scotch founder comes to England for his iron. The user may justly blame the blast furnace if his iron is hard when he asked for it soft, but he must not hold the maker responsible for fluidity or shock weakness, as it has been shown that the blast furnace has no control over phosphorus, simply transferring it to the pig, and the founder must change his district if his iron is too low in phosphorus. This study of phosphorus also reveals why hematite takes so much more breaking than the cheaper and commoner irons.

Influence of Silicon.

With certain definite requirements in view, it is comparatively easy to choose the phosphorus and hence the brand of pig, but there is no district from which iron can be bought with the certainty that it will contain a desired amount of silicon. It is, indeed, a most unreliable element, and even in calling for iron of a constant quality from one furnace, the foundryman may easily receive running deliveries of iron varying over a range of 2 per cent. silicon. It is not actually the most important element in pig iron, for carbon assumes this *rôle*, but because of its effect on this latter element, which is always at the mercy of an interloper, silicon becomes the element to which chief attention must be paid. The influence of silicon has been so much stressed that "grading by analysis" has been generally abbreviated to "grading by silicon," and it has come to be assumed that if the silicon content were specified by the buyer and supplied by the maker, the foundryman's millennium would be almost at hand. This is certainly a too-hopeful view of the case, but it has come about through the generally wide variation in the silicon content of almost any and every brand of pig, making it impossible for the founder to rely upon the most vital properties of his material. It may not be the most important element, but in buying pig-iron it is the most troublesome. Nevertheless, and in spite of all the preceding remarks, the writer is having exceedingly good deliveries with silicon varying only a few points, but this result has only come after persistent pressure.

The direct effect of silicon is so small, and its indirect effect so large, that the former is rarely taken into consideration. Of itself, it hardens iron to a small extent but adds to soundness in casting. Up to 3 per cent. silicon appears to increase fluidity, whilst over this amount the iron becomes "kishy," although it is notable that even then the molten metal flows more freely than its appearance would suggest. Other things being equal, the best skin is obtained on castings when silicon is between 2 and 3 per cent., this being superior both to the harder irons and to the high silicon or "kishy" irons mentioned above.

As an indirect influence silicon ranks first amongst the usual constituents, for by its aid the condition of the carbon can be almost perfectly controlled. It must certainly be admitted that silicon is not infallible in this respect, since foundrymen know that an iron with as much as 3 per cent. may be chilled to the point of whiteness, whilst on the other hand very low-silicon irons are occasionally grey. These latter anomalies are found in pig-iron, but it is rarely that they persist after remelting. Upon the final relationship between the two forms of carbon, *i.e.*, the hard form in combination with iron and the soft, weak, free graphite, may be said to depend the usefulness of the iron, and this ratio under normal conditions may be controlled by the silicon content. The total amount of carbon in pig-iron is important—perhaps more so than foundrymen at present understand, but it is not a factor entirely under control in making either pig-iron or castings. Efforts to bring down this amount below 2.75 per cent. are not successful, for even if in cupola working as much as 50 per cent. mild steel be included in the charge, carbon is absorbed during descent and melting until it reaches, at any rate, over 2.6 per cent., and a similar increase takes place if a low-carbon mixture from an open-

XUM

hearth furnace is remelted in the cupola. Furthermore, the form of the graphite in pig-iron is also a factor in making castings, for there would still seem to be retained after remelting some of the structural peculiarities or effects of the graphite. This is the only so-called "inherent" property for which there seems at present any foundation, but the important point is the amount of combined and graphitic carbon, for on this depends chill hardness, machinability, strength, soundness, and shrinkage. The condition of the carbon is influenced equally by section, for there are some sections so thin that they can scarcely be cast grey, and others so thick that it is difficult to retain them white without chills, and it is therefore impossible to show a definite relation between silicon and combined carbon or silicon and graphite. Turner, in his classical researches, has shown the amounts of silicon for maximum hardness, crushing strength, transverse and tensile strength, and machinability, but these figures only admit of literal interpretation into foundry practice when taken in conjunction with casting section. Keep, too, has given us curves showing the strength and shrinkage to be expected with varying degrees of silicon, but these are shown in the same curves to be variable according to the thickness or section of metal under consideration.

Influence of Sulphur.

Sulphur is an impurity which is often found to vary widely in what should be the same grade of iron, although more generally it varies inversely with silicon and does not often reach 0.10 per cent. when silicon is over 2.5 per cent. The author has on occasions received batches of iron with 3 to 3.5 per cent. silicon and sulphur over 0.15 per cent. Foundrymen are coming to realise that this element is less harmful than was formerly considered the case, and that good castings can be made even when it is rather high, but few have yet reached the stage at which they welcome an overdose as an act of friendship. Generally it is specified to be at a minimum, and any variation being then in an upward direction is to the prejudice of the material. Its presence in pig-iron is not readily detected, since the closening of grain or external chill which it may cause are more usually attributed to low silicon, and therefore where the foundryman has not the advantage of an analysis he may be unable to take those steps which partially counteract its influence. With high silicon, *i.e.*, over 2.5 per cent., a high percentage of sulphur is required, certainly over 0.125 per cent. to cause a chill even in light castings, but the chief defect then caused by its presence is loss of fluidity, the metal becoming comparatively viscous and then giving unsound castings. Without definite figures it is unwise to attribute a melt of this character, accompanied as it is by a strong smell of sulphur dioxide from the ladle, to high-sulphur pig-iron, as it more frequently arises from the coke. If it is definitely known to be from the pig-iron, high sulphur must in these cases be admitted as detrimental and often unavoidably so, for foundries making light castings only do not usually stock high-manganese pig, and would not be well advised to use it indiscriminately even where it is at hand.

In low-silicon pigs, where higher percentages of sulphur are more usually found, the effect of sulphur is even more readily seen in its liability to produce unsoundness and blowholes, but the castings made from this class of pig will benefit generally from such manganese additions as are likely to be used to counteract the evil. Sulphur has been spoken of as producing a chill, but this is only by its indirect effect on carbon, which is practically always, the hardness controller.

In addition to these defects—loss of fluidity, blowholes and chill—sulphur unaccompanied by manganese will also produce a degree of shrinkage which will cause cracking and flying in work of intricate design, and will cause a loss of strength in both tensile and transverse tests.

The key to avoidance of these troubles when exceeding the usually prescribed maxima for sulphur is the use of manganese in increased quantity. It has been seen that this element varies very widely when viewing as a whole the irons of this country, from 0.3 per cent. in Northampton pigs to 2.0 per cent. in North Staffordshire. This wide variation and the low percentage found in some brands makes it wise and even necessary to use a mixture of irons for almost any class of casting, for even with the commonest class of work it will be found that if low-manganese pig is alone used, it will not contain sufficient manganese to balance the sulphur, for it must be borne in mind that whilst manganese decreases with every remelt, sulphur increases. The actual amount of manganese for maximum benefit varies with the class of work in hand, being higher in heavier castings, but the two directions in which it exerts influence are both indirect—the one on sulphur as seen above, the other on carbon. Manganese helps to retain carbon in the combined or hard form, and hence toughens iron considerably, but it must obviously be used with moderation for light work. It has considerable influence on chill and shrinkage, independent of its action on carbon, and is used with advantage in chilled roll and similar work. In cylinder and similar work, manganese imparts a closeness of grain which enables a high degree of finish and polish to be obtained, but singularly this does not seem to apply to high-manganese pig-irons, which themselves are often very open in grain even when over 2.0 per cent. manganese. In fact, such a pig may be more open in grain than a Northampton iron with similar silicon but only one-eighth the percentage of manganese.

The properties laid to the credit of these various impurities are constant and unvarying, and may be relied upon to demonstrate themselves provided that the iron is normally melted and normally cooled. In cases where a certain feature present in a pig-iron—whether good or bad—does not remain after remelting, it may generally be said that this property is not the result of the composition of the pig-iron, but of some abnormal item in its production. The exceptions to this rule are the gains and losses in melting, which of course cause some alteration in analysis and may either bring some new quality into prominence or remove a feature before present.

Bearing this in mind, the pig-iron question can be surveyed with a much more open mind, for it becomes apparent that there is not nearly so much "bad" pig-iron as is often asserted. Of course, where a founder confines himself to one brand only, he feels the full effect of every variation, and must naturally condemn much of what he receives, but if he is in a position first to analyse his iron and then judiciously mix it, much that might in itself be useless becomes doubly useful, inasmuch as it may serve to make up some deficiency or other elsewhere. The trouble with pig-iron does not, in the author's opinion, lie in the amount of "bad" iron which the furnaces make, but in the faulty distribution of the iron, for "one man's meat is another man's poison," and whilst "A" may be pining for silicon and receiving none, "B," who is situated but a few miles off, may be wondering what he is to do with a much softer iron than he requires, actually received from the same furnace. Nearly all pig-iron is good when used for that purpose to which it is most nearly adapted.

Effect of Analysis on Properties of Pig-Iron.

From the foregoing summary of the characteristics of various brands and the effect of this analysis on properties, sufficient has been said to enable the following rules to be tabulated:—

(1) Castings of light section must have high silicon and those of thick section low silicon, in order to secure requisite hardness or softness.

(2) Castings of very light section must have high phosphorus to give necessary fluidity and length of life for pouring.

(3) Castings of heavy section should have lower phosphorus in order to shorten the range of solidification and limit segregation.

(4) Castings required to have strength above normal must have only medium silicon and phosphorus and low total carbon.

(5) All classes of castings should have manganese as high as is consistent with machinability in order to give close grain and neutralise sulphur.

(6) To resist wear it is of prime importance to keep silicon low and manganese high.

(7) For cylinder metals to withstand high pres-

sures use low silicon and total carbon and high manganese to give close grain.

(8) To obtain chill use very low silicon, depending on section, low total carbon, fairly high sulphur (not over 0.15 per cent.), and medium phosphorus and manganese.

(9) To withstand high temperatures keep silicon and carbon low, medium phosphorus, and high manganese. This metal is hard and brittle, has a high contraction, and may need annealing.

can be no truth in the assertion that any particular type of casting can be made successfully only from one definite brand or mixture, for it is found that similar types of castings are being made with success in every country where foundry practice is carried on. It will, however, be found that wherever a casting is made—that is successfully made—there is some relation in the final analysis of metal employed. Furthermore, analysis establishes a basis of comparison or communication between one country or another which cannot be similarly established by any other means, for whilst it might be of some guidance to pass on the analysis of a motor cylinder to a founder in Spain or in China, it would be of little use, either in theory or practice, to simply inform him that a mixture had been used of equal parts of Derbyshire, Northamptonshire, and Staffs cold-blast irons. Or, on the other hand, it would help a British founder very little to know that an American used "Hinkle" or "Warwick." In proceeding, therefore, to make any suggestions as to brands or types the author does so only with much caution and in a non-commital way.

TABLE IV.—*Pig Irons to be Used for Various Castings.*

Type.	Composition.	Irons Used.
		C—Cleveland. CB—Cold Blast. D—Derby (Common). SS—South Staffs. N—Northants. NS—North Staffs. H—Hematite. S—Scotch.
Light Work	High P. and Si.	N.—C.—D.—S.S.
Engineering— Medium heavy	Medium P. and Si. Low P. and Si.	S.—D.—C.—N. S.—D.—H.
High Strength	Medium Si. and P. Low C.	C.B.—S.—Specials.
High pressure and wear	Low Si. and T.C. high Mn.	C.B.—S.—N.S.—H.—Specials.
Chile	Low Si. and T.C. Med. P. and Mn.	C.B.—H.—S.—Specials.
High temperature	Low Si., Medium P. high Mn.	H.—N.S.

TABLE V.—*Analysis for Various Classes of Castings.*

Type of Casting.	Si.	S.	P.	Mn.	T.C.
Very light work	2.75	0.080	1.50	0.40	3.23
Sections 1 in. thick	2.25	—	0.75	0.50	—
Heavier than 2 in.	1.25	0.125	0.40	0.75	—
Motor cylinders	1.75	0.10	0.70	0.80	3.20
Motor piston rings	2.0	0.10	1.0	0.80	3.20
High temperature work	0.60	0.150	0.25	1.50	2.75
Chilled rolls	0.4 to 0.8	0.08 to 0.12	0.20	0.40	2.5 to 2.75
European malleable	0.70	0.25	0.08	0.20	2.80

TABLE VI.—*Analyses for Definite Classes of Castings.*

Castings.—	Light. Si.	Mn.	S.	P.	T.C.	Medium. Si.	Mn.	S.	P.	T.C.	Heavy. Si.	Mn.	S.	P.	T.C.
Acid-resisting	2.00	0.75	0.05*	0.20*	3.25*	1.50	1.25*	0.05*	0.20*	3.25*	1.00	1.25	0.05*	0.20*	3.25
Agricultural	2.50	0.60	0.06	0.75	3.75	2.25	0.70	0.08	0.70	3.50	2.00	0.80	0.10	0.60	3.25
Air cylinders	1.90	0.70	0.08	0.50	3.40	1.50	0.80	0.09	0.40	3.25	1.00	0.90	0.10	0.30	3.00
Annealing boxes	—	—	—	—	—	0.65	0.20	0.08	0.20	3.50	—	—	—	—	—
Automobile cylinders	2.25	0.65	0.08*	0.40*	3.25*	2.00	0.75	0.08*	0.40*	3.25*	—	—	—	—	—
Balls for grinding	—	—	—	—	—	0.75	0.50†	0.15*	0.40*	3.75†	0.50	0.50†	0.15*	0.40*	3.75†
Bedplates	2.00	0.70	0.08	0.60	3.75	1.75	0.75	0.10	0.50	3.50	1.50	0.80	0.12	0.40	3.25
Boiler castings	—	—	—	—	—	2.00	0.80	0.06*	0.20*	3.50*	—	—	—	—	—
Car wheels	—	—	—	—	—	—	—	—	—	—	0.65	0.50	0.08	0.35	3.50
Chilled castings	—	—	—	—	—	—	—	—	—	—	—	1.00	0.06*	0.20*	3.50*
Chills	—	—	—	—	—	1.00	0.50	0.05	0.20	3.00	—	—	—	—	—
Crusher jaws	—	—	—	—	—	1.00	1.00	0.04	0.20	3.50	0.80	1.25	0.06	0.20	3.25
Dies for hammers	—	—	—	—	—	1.50	0.60	0.05	0.20	3.00	1.25	0.80	0.06	0.20	2.75
Dynamo castings	2.50	0.50	0.05	0.75	3.75	—	—	—	—	—	2.15	0.50	0.06	0.50	3.25
Electrical work	3.00	0.50	0.03	0.60	3.75	2.75	0.50	0.05	0.50	3.50	—	—	—	—	—
Engine frames	—	—	—	—	—	2.00	0.60	0.08	0.50	3.50	1.75	1.00	0.10	0.40	3.00
Fire pots, grates	2.25	0.60	0.05	0.20	3.50	2.00	0.80	0.06	0.20	3.25	—	—	—	—	—
Fly wheels	2.00	0.50	0.05	0.50	3.50	1.50	0.60	0.06	0.40	3.25	1.25	0.70	0.08	0.30	3.25
Friction clutches	2.40	0.60	0.10	0.70	3.75	2.00	0.70	0.12	0.50	3.50	—	—	—	—	—
Furnace castings	2.40	0.60	0.05	0.60	3.75	2.15	0.80	0.06	0.50	3.50	—	—	—	—	—
Gas-engine cylinders	2.00	0.70	0.08	0.40	3.25	1.50	0.80	0.09	0.30	3.00	1.25	0.90	0.10	0.20	2.85
Gears	2.25	0.60	0.08	0.70	3.75	2.00	0.80	0.09	0.60	3.50	1.50	1.00	0.10	0.50	3.25
Glass moulds, pipe balls	—	—	—	—	—	2.50	0.60	0.04	0.20	3.25	—	—	—	—	—
Grate bars	—	—	—	—	—	—	0.60	0.05	0.20	3.50	—	—	—	—	—
Gun iron	—	—	—	—	—	1.50	0.50	0.05	0.30	3.25	1.00	0.60	0.05	0.30	3.00
Hardware	2.50	0.70	0.08	0.80	3.75	—	—	—	—	—	—	—	—	—	—
Heat-resistance-iron	—	—	—	—	—	2.00	0.80	0.06	0.20	3.25	1.50	1.00	0.06	0.20	3.00
Hydraulic-cylinder	—	—	—	—	—	1.50	0.80	0.05	0.40	3.25	1.00	1.00	0.08	0.20	2.85
Ingot moulds	—	—	—	—	—	—	—	—	—	—	1.25	0.80	0.06	0.20	3.75
Machinery castings	2.50	0.60	0.08	0.70	3.75	2.00	0.80	0.09	0.60	3.50	1.50	1.00	0.10	0.50	3.25
Mine wheels	—	—	—	—	—	0.90	1.00	0.10	0.20	3.00	—	—	—	—	—
Ornamental castings	2.75	0.60	0.06	0.90	3.75	2.25	0.70	0.08	0.80	3.50	—	—	—	—	—
Pipe (water)	2.25	0.60	0.06	0.80	3.75	2.00	0.80	0.08	0.70	3.50	1.50	1.00	0.10	0.60	3.50
Piston rings	2.00	0.70	0.05	0 60	3.50	1.75	0.80	0.06	0.50	3.25	—	—	—	—	—
Pulleys	2.40	0.50	0.05	0.70	3.75	2.15	0.60	0.07	0.60	3.50	1.90	0.70	0.09	0.05	3.25
Radiators	2.25	0.70	0.06	0.80	3.50	—	—	—	—	—	—	—	—	—	—
Rolls (chilled)	—	—	—	—	—	—	0.80	0.06	0.40	3.25	—	1.00	0.08	0.30	3.00
Soft castings	2.60	0.50	0.06	0.60	3.75	2.40	0.60	0.08	0.50	3.50	—	—	—	—	—
Soil pipe	2.25	0.60	0.08	0.80	3.75	2.00	0.80	0.10	0.60	3.50	—	—	—	—	—
Steam cylinders	2.00	0.60	0.08	0.50	3.50	1.80	0.80	0.09	0.40	3.50	1.25	1.00	0.10	0.30	3.50
Stove plate	2.50	0.50	0.06	1.00	3.75	2.25	0.60	0.08	0.80	3.50	—	—	—	—	—
Valves	2.25	0.60	0.07	0.50	3.25	1.75	0 80	0.08	0.40	3.00	1.25	1.00	0.09	0.30	2.85
White-iron castings	—	—	—	—	—	0.75*	0.20†	0.25	0.75*	2.50†	—	—	—	—	—

* Below. † Above.

Tables IV, V, and VI show respectively the uses of various brands for different types of castings, analysis required for a number of representative castings, and American standard analyses.

The suggestions as to brands to be used are put forward very tentatively, and only to show the choice offered for each grade of casting. There

Assuming that a foundryman has to make a quantity of any particular type of casting, he will first have to decide if this can be made from any mixture of iron at present in use or if the limits in requirements are so specialised and narrow that a new mixture will be required. In the latter case he will either have before him the specified

analysis or will decide from the physical requirements the general outline of composition, and will then be in some position to select his irons. He will naturally desire to use local irons where possible owing to the considerable saving in railway carriage, but this cannot be made the first principle of selection. It has been shown that phosphorus is generally constant in the iron from one district, and that a furnace cannot supply phosphorus to specification in the same way as silicon. This does not apply to any element in the same degree, and therefore the author's suggestion is that phosphorus first be considered. If a high percentage is allowable, then cheap Northampton or Cleveland iron may be bought, but if only a low percentage then these are cut out at once. The rule is inelastic, for whilst no high-phosphorus iron could be used in obtaining a final 0.10 per cent. P. mixture, it is most inadvisable to use a proportion of such irons even where 0.50 per cent. is finally allowable, for it is not good practice to melt together very dissimilar irons, and such a proposition as that just mentioned would necessitate using hematite to balance the high-phosphorus component.

Influence of Carbon.

It has been shown firstly that there are few irons with low carbon, and secondly that even if the pig could be obtained very low in this element the advantage is largely lost in the cupola, where there will be an increase to at least 2.65 per cent. If the castings are to be specially strong or to withstand very high pressures, it will be necessary to keep the carbon low, and whilst there may be some chance of doing this with low-carbon pigs, there can be no chance if the carbon is high at commencement. The selection here may even assume a greater importance than in the case of phosphorus, and it may be necessary to abandon hematite, which is a high-carbon iron, and to turn to special cylinder irons or to cold blast. The special cylinder irons are often made in refining cupolas by the admixture of heavy percentages of steel, and the question may therefore arise of the possibility of a semi-steel mixture being adopted. The advantage of buying one of these steel-mix pigs is that the second melting in the foundry cupola ensures thorough uniformity where this may not be certain by merely melting pig with steel scrap, but in the author's opinion lower carbon may be obtained in home-made semi-steel than in remelted steel-mix pig. With moderate care there is no difficulty in melting semi-steel up to 50 per cent. steel, and the author has, in fact, been able to do this on a half-ton cupolette and obtain a metal suitable for even the most stringent requirements.

Semi-Steel Mixtures.

The scope of this Paper does not include the consideration of steel mixtures, but the author cannot leave this part of the Paper without saying that the use of steel in cupola mixtures opens up for the foundryman an entirely new field of material, and *that* without using expensive pig-iron. It is for this reason that the table of suggested brands is put forward only with hesitation, because it is felt that steel mixtures could be used alternatively with those mentioned and at a considerable saving, and had the Paper allowed for this, a new set of mixtures might have been put forward. Nearly every requirement of the foundry can now be met by the admixture of steel with various classes of pig-iron.

If a moderate percentage of manganese is required, it may be necessary to go outside the immediate locality to obtain this, even if phosphorus and carbon are suitable in the local supply. It has been shown that Scotch and Lincolnshire irons contain well over 1.0 per cent. manganese; some Derbyshire also up to 1.2 per cent. and North Staffs up to 2.0 per cent., so that in no case is it necessary to bring Scotch iron to Birmingham, etc. The North Staffs high-manganese pig is in some cases too high in phosphorus for foundry requirements, and needs to be melted along with a lower-phosphorus iron or with steel.

The consideration of silicon requirements may be left until last in selecting pig-irons, as wherever the founder may have to go for high or low phosphorus, manganese, or carbon, he will find generally a sufficient range of silicon content to meet his particular requirement, and will in fact probably have examples of this wide range brought to his notice in a comparatively short time. There are, of course, some furnaces which only make high- or low-silicon iron to special requirements, but these are the exception, and therefore, although silicon is so important, it need not be the first consideration.

Assuming that the mixture will require 25 per cent. each of Northampton and Derbyshire irons, the user is left with considerable latitude in the actual selection of his furnaces. This will, in fact, vary from time to time with market supplies and conditions and with the rate of delivery required; but it will be found that although the irons from any given district have much in common, they cannot always be freely interchanged. In the Northampton irons, for instance, with 2.5 per cent. silicon, there is a marked difference in grain between certain of the irons with which the author is in contact, and the same is true of other districts; but generally there is plenty of scope for interchange, thus giving to the purchaser a freedom of action which he would be denied if tied to one brand.

Some foundrymen make their mixtures by the use of a small proportion of each of a large number of irons, relying upon some form of the law of averages to level up the inconsistencies and eccentricities of any of the brands which may be behaving unseemly. These people never change their brands and are thus in the hands of the sellers. Other foundrymen keep the same brands always, but vary the proportions with the fractures, which is more scientific than the first method, but is open both to error, as all fracture-mixing is, and to abuse from the furnaces. Others again wait until trouble comes and then add some "dope," to which they pin their faith because of its high price. Still others work to a fixed analysis, and so long as this is obtained are regardless of the components thereof; but this method has been shown by various workers to fail at times, for vast changes in physical properties have accompanied the substitution of one iron by another of apparently similar analysis. The author has always worked to a narrow range of analysis and has kept constant as far as possible the proportions of iron from various districts, but freely interchanging the brands from each district so far as possible. But few exceptions to this practice have been found, mostly in cases where it at present appears that a certain brand of iron displays a strong tendency to draw or to give dirty castings. In not every case has a sufficient reason been assigned for the restriction of liberty in interchanging all components so long as a desired analysis is obtained, but no foundryman likes to acknowledge that no other iron but the one he is using will meet his case.

Catalogues Received.

Electrical Supplies.—We have received from Messrs. Donovan & Company, 47, Cornwall Street, Birmingham, a catalogue of the electrical fittings they factor.

Welding Rods.—Messrs. The Suffolk Iron Foundry (1920), Limited, of Stowmarket, have sent us a well-produced sixteen-page brochure dealing with cast-iron welding rods and fluxes. This is the second and an enlarged edition, the first of which was reviewed in these columns some months ago.

A NEW WAGES AGREEMENT arrived at by the Joint Conciliation Board, representative of the Brassfounders Employers' Association of the National Brass and Metal Mechanics' Society, has been finally approved. It provides for an advance of one penny per hour to men of all grades. The agreed bonus will therefore be 21s. 6½d. per week of 47 hours. The bonus for youths between 18 and 21 is to be increased by ½d. per hour, making their total bonus 11s. 4d. The new wage advance will take effect on the first pay-day in May, for work done in the previous week. The arrangement will continue for six months definitely, and after that it can be terminated by either side on giving three months' notice.

Fluxes and Slags in Metal Melting and Working.

A general discussion on this subject was held last Monday, at the Institute of Mechanical Engineers, under the joint auspices of the Faraday Society, the Institute of Metals, the Institute of British Foundrymen, and the British Non-Ferrous Research Association. For the first part of the proceedings Prof. Turner, President of the Institute of Metals, was in the chair, and for Part II Sir Robert Robertson, K.B.E., President of the Faraday Society. A series of Papers were read, a selection of which are abstracted below.

OXIDISING FLUXES IN THE MELTING OF NON-FERROUS METALS.

By A. PORTEVIN.

[*Slightly Abridged.*]

In the great majority of cases the *rôle* of fluxes employed in melting and soldering of non-ferrous metals and alloys may be classified as follows:—

1. *As a protection*, forming a liquid covering on the surface of the metal, which prevents the oxidising action of the air. This is the *rôle* of melted chlorides for alkali metals, and metals of the alkaline earths, aluminium and magnesium.

In the use of these fluxes, it must not be forgotten that certain of these chlorides are capable of being hydrolysed, and can consequently take part in the corrosion of the metals under which they are melted.

2. *As a reducing agent.* That is to say, to bring back to the metallic state the oxide of the melted metal, while forming a new oxide easier to eliminate. As an example, one may quote certain fluxes containing manganese or carbon used in the copper foundry.

3. *As a melting agent.* Acting by dissolving the inclusions and oxides of the molten metal, or the oxides resulting from the reducing action of the deoxidisers. They facilitate also the elimination of the inclusions, and modify the surface tension, particularly when the oxides form an elastic film on the surface of the melted metal (as in the case of aluminium and its alloys). This is the *rôle* of borax in melting copper, or cryolite for aluminium.

4. *As an agitator*, by evolution of gases and vapours, stirring up the metals, and helping the inclusions to rise. This is, for example, the action of volatile ammonium chloride in the aluminium foundry.

Certain particular metals melted with alkaline fluorides, as well as being cleaner, are slightly more affected by the air, due, no doubt, to the presence of traces of sodium.

The composition indicated for certain fluxes used in foundries (bronze, brass, nickel silver, etc.) is clearly oxidising, since they contain nitrates, manganese dioxide, etc. The action of these fluxes has never been clearly demonstrated, in which connection the following industrial experience which happened to us is recalled, and which clearly shows that the addition of an oxidising substance can have a beneficial effect in avoiding blow holes due to the reducing gases.

The great majority of bronze castings from a metal melted in a heavy oil furnace with direct heating of the metal by the flame of a blow-pipe were riddled with a number of small blow-holes; these blow-holes occurred whatever method of pouring, the shape of the castings, their position in the mould, and their feeding, was used, or whatever the care taken in the preparation and drying of the moulds and cores.

After careful examination of the blow-holes with a lens, it was observable that the cavities were round in shape without inclusions of foreign matter, and appeared clean and unoxidised. It was naturally thought that they were the result of bubbles of reducing gas previously dissolved in the liquid metal and liberated in the mass during cooling following casting. This abnormal absorption of reducing gas by the molten metallic bath is due, apparently, to the method of heating creating in the furnace a very reducing atmosphere.

To prevent this state of affairs the author had the idea of supplying, previous to melting, an oxidising body in the nature of a metallic oxide. As the bronze used had to contain a small quantity of lead (the composition being Cu = 88, Sn = 6, Zn = 3, Pb = 3), he introduced oxide of lead in the form of litharge (PbO), or, better still, red lead (Pb_3O_4), in a sufficient quantity to allow the right amount of lead in the final mix, taking into account the reduction looked for, so that there should be no inconvenient consequences.

The method of proceeding was as follows:—The metallic bath of about 300 kgs. was melted and maintained at the convenient temperature; the surface was skimmed and sprinkled with about 0.05 per cent. red lead, the melt was stirred and the casting proceeded with, with the usual precaution.

The result obtained completely verified conjecture. The trouble described disappeared completely, and a practice of several years confirmed the accuracy of our interpretation.

A highly reducing atmosphere appears then to present inconveniences, for which it is possible, as indicated, to devise a remedy; on the other hand, an oxidising atmosphere is also a cause of defects owing to the production of inclusions of oxides.

THE USE OF FLUXES IN BRASS MELTING.

By R. GENDERS, M.Met., and M. A. HAUGHTON, A.R.S.M. (Woolwich).

[*Slightly Abridged.*]

So far as the authors are aware, it is not claimed that the melting of brass is a refining operation in which elimination of impurities occurs, and it may be taken that it consists substantially in the mixing together of the two metals copper and zinc with whatever impurities they originally contain. Both metals tend to oxidise readily, and the total oxidation of both results ultimately in oxidation of zinc alone, since any copper oxide is reduced by zinc. The only other harmful materials appear to be the foreign matter associated with the scrap, and material of similar character derived from the walls of the crucible.

The necessity for the use of materials which can be termed fluxes may be therefore based on:—(1) The avoidance of oxidation throughout all stages of the process, and (2) the collection and elimination of foreign matter.

The first of these is accomplished to some extent during the first stages of melting (*i.e.*, the fusion of the copper and scrap) by the generation of reducing gas from added charcoal. Copper cannot be entirely deoxidised, however, by this means, and the addition of zinc inevitably results in the formation of a certain amount of zinc oxide. Fluxes are frequently used before and after addition of the zinc, the most common being common salt, glass, borax, salt cake, silica, bone ash, plaster of Paris, boracic acid, carbonate of potash and caustic soda. The actual result of the use of these fluxes in their function as reducing agents, collectors of zinc oxide or collectors of foreign matter is known only in indefinite terms from the experience of brass melters, among whom there is considerable difference of opinion, and no quantitative data exist. The small amount of available literature on the subject deals mainly with observational work, unsupported by experiment. A complete investigation of the action and value of fluxes presents considerable difficulty, especially in the isolation of set conditions. It is, however, suggested that results of considerable value could be obtained by determining the relative effects of the methods at present in use. The authors' experimental work has not yet reached a stage at which conclusions of immediate practical value can be drawn, and this Paper is contributed with the primary object of obtaining views from as many standpoints as possible on the use

of fluxes in brass melting, which, while constituting one of the largest branches of the non-ferrous metals industry, has hitherto been neglected by the scientific investigator.

It was found that the addition of dry zinc oxide to 70/30 brass, carefully prepared from virgin metals, produced no more inclusions than could be detected in similar brass to which no oxide had been added. It is evident that zinc oxide added in this manner is not wetted by molten brass. The addition of fluxes such as borax, salt, calcium fluoride, potassium nitrate and charcoal with the zinc oxide produced numerous inclusions which, under conditions of slow solidification, tended to concentrate near the top surface of the metal. The inclusions were dark grey in colour, and all the fluxes used gave inclusions of similar appearance, suggesting that they consisted mainly, though possibly not entirely, of zinc oxide. This view is supported by the facts that the inclusions were rapidly blackened on etching, and that when inclusions of flux alone were intentionally produced they tended to drag from the surface during polishing, leaving holes and scratches.

The action of charcoal in promoting the formation of inclusions is possibly due to the fluxing action of the materials constituting the ash. A curious feature observed was the occasional formation by the included matter of six-rayed stars. Their hardness is considerably greater than that of the brass, but below that of hard steel.

A further method employed for the introduction of zinc oxide was the addition to the brass of cuprous oxide. The only material present that might have acted as a flux in this case was the silicious element in the walls of the crucible.

Small ingots of 70/30 brass, oxidised by means of cuprous oxide, were made to fit an electrically heated graphite crucible 6 in. in height and 1 in. in internal diameter. A recess was machined in the base of each ingot into which borax was pressed and covered by a tight-fitting brass disc. On heating, the borax rose partly round and partly through the liquid metal, which was maintained at 1,100 deg. C. for 15 minutes and allowed to solidify slowly. The borax on analysis was found to contain 7.8 and 7.9 per cent. zinc in duplicate experiments. Sectioned ingots of the oxidised brass showed numbers of small grey inclusions, indefinite in form. The metal treated with flux contained very few inclusions. A considerable decrease in the number of inclusions resulted from retaining the metal at rest in the molten state for 20 minutes. The method cannot be developed to give quantitative results until means are devised for determining the amount of oxide present in the brass, since a considerable quantity floats to the surface of the liquid metal immediately after the oxidising operation. It is probable that glass and salt would show a similar effect in removing suspended oxide, since both dissolve zinc oxide. Salt volatilises, and is readily absorbed by the crucible, showing a loss of about 50 per cent. on heating with zinc oxide at 1,100 deg. C. for 15 minutes. Borax and glass show no appreciable loss under the same conditions.

A further series of experiments was made by pouring roughly equal quantities of oxidised brass into small crucibles containing molten weighed quantities of borax, glass and salt, and maintaining the temperature of the mixture for 15 minutes at 1,100 deg. C. before allowing to solidify. The brass and slag were weighed and the slag analysed for zinc and copper, except in the case of the salt flux, which appeared to have been absorbed to a large extent. Assuming equal oxide contents in the separately poured quantities, and allowing for the original zinc content of the glass, it was found that the glass showed an efficiency in removal of oxide greater than that of borax in the ratio of 5 to 3. These preliminary results have not yet been confirmed, and the method will need modification before accurate results can be obtained.

The small number of preliminary experiments made indicate that when zinc oxide is formed during the melting of brass a large proportion rises quickly to the surface. The suspended oxide remaining may be largely eliminated by the stirring in of a suitable flux such as borax or glass or by a period of rest. Possibly a further small amount may exist in a fine state of suspension, but it is questionable whether the brass is appreciably affected by its presence. Removal of final traces could only be effected by a long period of rest or the adoption of methods based on the present knowledge of colloids.

Observations during the small-scale experiments suggest that in commercial brass manufacture the inclusions present in the ingot are not all derived from suspended matter in the fluid metal. Under ordinary conditions of casting, inclusions of material from the surface of the fluid metal may easily be introduced accidentally into the ingot. Oxidation of the stream of metal during pouring is another possible source of inclusions.

In general, the proportion of inclusions in commercial brass, as estimated by microscopic examination, is not greater than in steel of ordinary quality. It is suggested, however, that the mechanical qualities of the metal and the quality of polished surfaces might be improved by more complete elimination of non-metallic inclusions.

NOTE ON SLAGS FROM LEAD, COPPER, AND OTHER BLAST FURNACES.

[*Extract.*]

Mr. Gilbert Rigg, the author of this Paper, is the consulting metallurgist to the Zinc Producers' Association in Australia. He points out that the condition of the slag when once withdrawn from the furnace is different from those existing within the furnace. After touching upon the probable influence and importance of dissolved gases in slags, especially upon the fluidity, he outlines the characteristics of a mangano-spiegel slag.

The ideal (non-ferrous) blast furnace slag is stated to exhibit the following properties if it is the fused product of the gangue of the ore:—(1) It must flow freely from the tap-hole; (2) it must not deposit accretions in the furnace; (3) its capacity to dissolve valuable metals must be a minimum; (4) it must be as small in amount as possible; (5) the fluxes entering into its composition must be obtainable at minimum cost; (6) it must admit of fast running and good reduction of the charge; (7) it must give a clean separation from metal, matte, or other valuable products; and (8) if in addition it has a value as a by-product, so much the better.

The slag produced at the Port Pirie (S.A.) smelters has the following average composition:—Silica, 20.1; oxide of iron, 28.2; oxide of manganese, 3.9; lime, 11.0; magnesia, 2.0; alumina, 6.2; oxide of zinc, 22.1; and sulphur, 2.7 per cent. At times the silica content falls as low as 17 to 18 per cent. without any deleterious effect.

A detailed description of this slag is given, and an example taken from lead smelting practice is given to illustrate the nature of the chemical equilibria at high temperatures.

SLAGS PRODUCED IN MELTING SILVER ALLOYS.

By JOHN PHELPS.

[*Abridged.*]

In the years 1920, 1921 and 1922 the Mint has had occasion to melt and cast into flat bars for rolling large quantities of an alloy of the composition, silver 50 per cent., copper 40 to 41 per cent., nickel 10 to 9 per cent. This alloy is only perfectly melted above 1,180 deg. C., and consequently had to be poured at about 1,250 deg. C., while the alloys of silver and copper previously used were best poured at about 1,050 deg. C.

In order to obtain sound castings and malleable metal it was necessary to add a deoxidiser to the melt; the protection afforded by a cover of charcoal fragments being insufficient. Metallic manganese and 8 per cent. phosphor copper were found most effective, and the resulting oxides formed slags with the silicates from the crucibles, stirrers, and covers, which gave some trouble in pouring.

The alloys of silver and copper only, did not require a deoxidiser, and the small quantity of copper oxide produced at the lower melting temperature adhered to the crucibles or stirrers and caused no trouble; there was no evidence of a fluid slag in these cases. When 0.05 per cent. each of

metallic manganese and phosphor copper (8 per cent. phosphorus) were used with the above silver copper nickel alloy, a very viscous slag was formed which could be kept out of the moulds without much difficulty, but which adhered to the crucibles and stirrers, to a troublesome extent in the case of the latter. The metallics left after crushing and sieving a sample of this slag contained silver to the amount of 4.8 per cent. of the slag, which therefore must have retained nearly 10 per cent. of metal. It also contained some carbon from the stirrer, which consisted of a graphite and clay composition.

After crushing and roasting, this slag was only partly decomposed by concentrated hydrochloric acid, and hardly at all by fused potassium bisulphate. Fusion with sodium carbonate for an hour produced complete decomposition.

This slag proved to contain :—SiO_2, 13.3; Al_2O_3, 19.6; FeO, 12.5; MnO, 32.8; CuO and NiO, 0.1; and P_2O_5, 0.3 per cent., the remainder being lime and alkalies.

When 0.10 per cent. of metallic manganese was used alone as deoxidiser a more fluid slag was obtained, generally in small quantities which adhered to the crucibles and stirrers, but occasionally in quantities which gave trouble owing to its being carried over into the moulds and forming inclusions in the castings. This slag included only about 0.5 per cent. of metal, and a sample had the composition :—SiO_2, 32.4; Al_2O_3, 7.9; FeO, 7.9; MnO, 40.3; CuO, 0.2; NiO, 0.5; and CaO and alkalies by difference, 10.8 per cent.

The greater fusibility of this slag is evidently to be attributed to the increased proportions of silica, not to the absence of phosphorus, which was only present in negligible amount in the more viscous slag produced when phosphor copper was used.

This fusible slag was only obtained in some melts, and it was noticed that the furnace covers were so much fluxed on the under side that fused slag must at times fall into the crucibles. The slag was derived from the fluxing of the highly silicious cover (Glenboig fire-tile) with the charcoal ash and other basic material carried up by the furnace gases. A portion of the fused surface of the covers was found to contain 51 per cent. of silica, showing that some basic material had been added to the constituents of the fire-tile.

It would appear that, while the substitution of the equivalent amount of phosphor copper for half the necessary manganese produces a smaller quantity of a more infusible slag, the difference is not great and does not outweigh the other drawbacks to the use of phosphor copper. A fusible slag could be obtained in all cases by suitable addition of sand or glass, but in Mint practice a viscous slag is more readily excluded from the castings.

The most fusible slag obtained included enough silver to make treatment for the recovery of the metal necessary, which can be readily done by fusing the slag with sand or borax. The silver could be recovered from the more viscous slags by the same treatment, and owing to their smaller bulk no more of the fluxes were required.

In melting metal of less value it might be preferable to produce a fluid slag, provided that the latter could be rejected without recovery of the contained metal. Subsequent experience with an alloy of the composition copper 70, silver 25, manganese 5 per cent., shows that similar slags are produced, though naturally in larger quantity.

SULPHURISING AND DESULPHURISING OF METALS BY BASIC SLAGS AND FLUXES.

By B. BOGITCH.

[*Abridged.*]

Desulphurising of Metals in the Molten State.

Method of Operation.—One hundred grammes of metal (copper, nickel, iron or manganese), with the addition of a similar quantity of sulphur, were melted in a graphite crucible at a temperature of 1,500 to 1,600 deg. C. in a small electric granular resistance furnace.

When completely melted, 20 grains of desulphuriser (lime, limestone flux, lime and fluor-spar) were introduced into the crucible, and agitated by means of a carbon rod. At the end of a given time the metal is poured out and the slag collected.

Desulphurising with Lime or Flux.—If the metal be rich in sulphur, much of the latter is absorbed by the powdered lime. If, on the other hand, it contains a small percentage or fractions of a per cent. of sulphur, the desulphurising by pure lime or basic flux becomes extremely slow. With these desulphurisers there is no certainty at any moment that equilibrium is attained. This is accounted for not only by the high viscosity of basic fluxes, which makes diffusion of the lime or calcium sulphide very slow, but also by the feeble solubility of the latter in the fluxes. Thus, according to the experiments, a flux of composition $2SiO_2$, Al_2O_3, 2CaO can only dissolve 3.8 per cent. CaS, that is 1.7 per cent. S.

Desulphurising by Lime Dissolved in Fluor-spar.—To obtain rapid desulphurising the lime must be dissolved in a solvent of which the properties are different from those of fluxes habitually used in metallurgy. Such solvent exists in calcium fluoride, indicated by Rollet.* Much less viscous than the ordinary basic flux, it can also dissolve more than 20 per cent. sulphur, and several parts per 100 of iron or manganese sulphide.

Table I outlines several results obtained with a desulphuriser composed in equal parts of calcium fluoride and lime:—

TABLE I.—*Showing the desulphurisation of Metals by Ca F_2 and Ca O flux.*

Duration of experiment in minutes.	Sulphur Content in 100 parts of metal.		Sulphur content in 100 parts of flux.
	Before desulphurising.	After desulphurising.	
	Iron.		
20	6.0	0.35	21.23
30	1.7	0.015	8.15
	Nickel.		
30	7.2	1.61	21.78
30	4.1	0.006	16.68
	Manganese.		
45	1.4	0.04	2.90

With the desulphurising mixture indicated above, the flux ceases to absorb sulphur when its content of this element is in the neighbourhood of 22 per cent. It is then almost solid at the temperatures used, 1,500 to 1,600 deg. C. Analysis showed that there still remained a little lime uncombined with sulphur in the flux. If the proportion of fluoride in the mixture be increased, the absorption of sulphur by the flux continues until all the free lime is transformed into sulphide.

The results of the experiments do not enable one to calculate exactly the coefficients of absorption of sulphur for the different metals studied, but they partially indicate their order of magnitude. Thus, in the case of iron, the sulphur absorption of the flux can be more than 500 times as great as that of the metal. For nickel or copper this coefficient of absorption is still greater (more than 2,000). With manganese, however, it is smaller than with iron.

Thanks to these coefficients being as high as they are, it is possible to prepare, at least in the laboratory, pure metals, by separation directly from their sulphides, eliminating in consequence roasting and reduction.

Desulphurising of Metals in the Solid State.

Certain metals—steels, for example—heated in a closed chamber in the presence of carbon, have their sulphur content reduced. Actually, this desulphurising is very slow, and affects only quite superficial layers of the metal. It is not therefore a method of practical importance for dense metals obtained by fusion.

It is quite otherwise, however, for metals like nickel or cobalt obtained industrially as agglomerates (cubes, rondelles, bricks). These are extremely porous bodies, consequently presenting considerable surface of action, though of small volume. In this case, desulphurising is much more rapid. It is produced both in the interior as well as the exterior of the agglomerate. In this

* The fluoride may be replaced by chloride as has been proposed by Saniter.

way very considerable changes can be effected in both the chemical composition, and consequently in the mechanical properties of the metals.

Laboratory Experiments.—Oxides of nickel or cobalt containing 0.01 to 0.02 per cent. of sulphur were ground to grains of a few hundredths of a mm. dia., made into a paste, and moulded into cubes whose sides were 15 mm. After drying, these cubes were submitted to a reducing calcination for varying times and at different temperatures.

As reducers, carbon (from sugar), anthracite and charcoal were used. Each kind of reducer was used in powder form, and either by itself or in a mixture with alkaline carbonates, or alkaline earths.

Table II gives some results of desulphurising obtained at 1,100 deg. C., after calcination for 12 hours:—

Table II.—*Reduction of S. in Solid State by Carbon.*

	S. per cent.
Oxides before reduction	0.018
Cubes after reduction in:—	
Sugar carbon	0.019
Anthracite	0.028
Wood charcoal	0.010
Wood charcoal, with 5 per cent. $CaCO_3$	0.005

Thus the reduction of these oxides by means of a very pure carbon, such as is obtained by sugar calcination, does not result in desulphurising: furthermore, anthracite containing originally 0.50 per cent. sulphur gives up its sulphur to the metal; on the other hand, wood charcoal, especially when mixed with carbonates, reduces very perceptibly the sulphur content of the metal.

A more profound study of the question has shown that desulphurising does not begin until after the complete reduction of the oxides, and simultaneously with the carburisation, that it is due to the presence of carbonates, and that consequently any form of carbon with addition of this salt will suffice.

Although in the experiments only small quantities of sulphur—0.013 per cent. in the most favourable case—were removed, the results are nevertheless very interesting, because this desulphurising, although slight, appreciably modifies the mechanical properties of the metal. For instance, a nickel cube containing before desulphurising 0.015 to 0.020 per cent. sulphur is reduced to dust at the first blow of a hammer; but the same cube, other things being equal, but with 0.005 per cent. sulphur, can be transformed by hammering into a disc of a few mm. in thickness, without breaking.

SLAG INCLUSIONS IN RELATION TO FATIGUE.

By Professor B. P. Haigh, D.Sc.

The general view, based on practical experience, that slag inclusions in an otherwise sound metal tend to promote fatigue, is supported by experimental research, but appears to require further investigation. It is probable that different slags have widely different effects; and also that the effect of a given slag may depend on how the stress varies—whether as a pulsating or as an alternating stress that reverses its direction.

Considerable difficulty is experienced in analysing the results of fatigue tests, to ascertain the effects of slag, because it is seldom possible to compare two samples that differ only in the character or amount of slag present. Experimental evidence indicating the harmful effect of slag may be classified in three categories, as follow:—

(1) When a machine part or test-piece fails prematurely under a moderate range of stress that might be expected to be safe, it is commonly observed that the crack starts from a slag vein and thence spreads through sound metal, forming a characteristic fracture with shell-lie markings. The appearance suggests that the vein acts as a scratch or other discontinuity of form; thus the cracks start from both sides of the vein, where projections are discernible, and do not commonly cross the vein.

(2) In determining the fatigue limit of a sample of metal, it is customary to test a number of identical test-pieces under different ranges of stress and to record the endurances—which may run from a few tens of thousands to several millions of cycles of stress before fracture occurs. On plotting the stresses against the endurances, the points are found to lie on a regular graph if the metal is of uniform quality, or in a zone bounded by a pair of similar graphs if the metal be non-homogeneous. The width of the zone intercepted between the two graphs often affords some quantitative measure of the influence of slag inclusions irregularly distributed through the metal.

(3) Considerable experience of fatigue testing indicates that, although the ratio between the fatigue limit and the tensile elastic limit varies very widely in different metals or in the same metal with different heat treatments, and may be either greater or less than unity, the ratio between the fatigue limit and the ultimate tensile strength varies only in less degree,* at least in metals free from slag. The value of this ratio appears hardly ever to exceed 0.60, which value is reached only in the best qualities of drawn bronzes and in the mildest steels and irons free from slag; and seldom falls below 0.40 in metals free from slag inclusions. Since the presence of slag, however, reduces the tensile strength only slightly, and the fatigue strength in much greater degree, the value of the ratio falls when slag is present.

The influence of slag inclusions varies considerably in different methods of testing. In the Wöhler fatigue test, in which the test-piece is a rotating beam or cantilever, subjected to bending stresses that reach their nominal value only in the surface layer of metal, the presence of a slag particle near the axis has no influence on the result of the test. On the other hand, a particle on or near the surface reduces the strength greatly. In another method of testing, as used by the author, a stationary test-piece is subjected to direct pull or push produced and measured by means of a pair of alternating-current magnets. In such a test-piece, the stress is uniformly distributed along the whole of the cylindrical portion of the bar, and across the whole cross-section: a considerable body of metal is subjected to the nominal range of stress, and a slag particle anywhere in this body of metal promotes the same tendency to accelerate fatigue.

The effect of slag in such circumstances is illustrated by the following figures for a manganese bronze containing small particles of slag. The tests were made with stresses alternating between equal values of pull and push, with a frequency of 2,000 cycles per minute.

Chill cast. Ultimate tensile strength 23.1 *tons/ins.*^{2}
Range of stress ± 6.64 tons/ins.^{2}
Endurance 48,000 cycles,
Range of stress ± 6.64 tons/ins.^{2}
Endurance 160,000 cycles.

Sand cast. Ultimate tensile strength 20.0 *tons/ins.*^{2}
Range of stress ± 6.64 tons/ins.^{2}
Endurance 56,000 cycles.
Range of stress ± 4.91 tons/ins.^{2}
Endurance 25,000 cycles.

Although the tests were not continued at lower ranges of stress to ascertain the precise value of the fatigue limit, it is clear that this cannot have been more than 20 per cent. of the ultimate tensile strength, and was probably less. In such an alloy, if free from slag, the ratio would not probably have been less than 40 per cent.; so that one may safely infer that the small slag particles reduced the fatigue strength in ratio 2:1.

On the other hand, experiments show that, in wrought iron of good quality, but containing small veins of slag rolled out in the direction of action of the stresses applied in the fatigue tests, the value of the ratio fatigue limit/ultimate tensile strength, falls only in much less degree. In wrought iron of ordinary qualities, the ratio value may commonly exceed 50 per cent.

While the ultimate nature of fatigue remains uncertain, even in the simpler case of a metal free from slag, it may be premature to discuss the

* B. P. Haigh, "Journal West of Scotland I. and S. Inst., 1915"; also B. P. Haigh, "Institute of Metals, 1915."

theoretical aspects of the influence of slag. But certain considerations appear to merit attention.

Ample evidence is available to show that a fatigue crack, having once been opened at some zone of weakness, will spread through sounder parts of the metal. From the same evidence we may deduce the important conclusion that any weakness in fatigue, induced by the presence of slag, will not increase in direct proportion to the amount of slag present, but will depend more directly on the relative physical and chemical properties of the slag in contrast with the metal. If the particles of slag are not exceedingly finely divided, a little slag is likely to be as harmful as would be a greater quantity, it being understood that the total quantities are small in comparison with the bulk of metal. It may be expected, therefore, that the influence of slag, in fatigue, may be correlated to qualitative rather than to quantitative analysis; and that progress may be effected by the selection of a harmless slag, rather than by more complete elimination.

There appear to be at least three distinct ways in which slags may influence the fatigue strength of a metal; as follow :—

(1) *Chemically.*—The slag may supply elements or compounds that enter into solution in the metal, so that it becomes brittle. But since the fatigue limit of even a brittle solution is quite commonly higher than that of the ductile solute metal, it appears improbable that this action is generally important. In certain circumstances, however, the presence of such a brittle layer, surrounding the slag, might definitely accentuate the actions mentioned below.

(2) *Expansively.*—Since the thermal expansions of slag and metal usually differ widely, the process of cooling may cause the slag to exert severe stresses, acting as fluid pressure or as shear stress, and of such intensity as may strain the surrounding metal beyond its elastic limit. Or the slag may shrink away from the metal, forming a cavity.

(3) *Elastically.*—Since the elastic constants of the slag and metal differ widely, any applied load will produce concentrations of stress at and near the boundary zones between the slag and metal, even though the surfaces may be, initially, free from stress.

The influence of slag must depend also, like the influence of a rivet hole, on the character of the stress variations during the cycle of loading. This latter action has been investigated experimentally, and in a ductile metal the effect of such a discontinuity is only slight, and much less than is indicated by mathematical or optical theory, when the stress pulsates without changing its direction. When the stress reverses its direction, or the metal is of harder nature, however, the liability to fatigue near a rivet hole is greater and approaches the values indicated by theory. It may be expected that the influence of slag discontinuities will vary in similar manner; and that ductile metals, subjected to stresses that pulsate without changing direction, may be comparatively immune from the ill-effects of slag inclusions, provided that these are small in comparison with the sections of the parts.

FLUXING PROBLEMS IN WELDING MILD STEEL WITH THE METALLIC ARC.

By H. OGDEN, B.A., B.Sc.

[*Extract.*]

The substance of this Paper is expressed in the three tables which are reproduced below.

TABLE I.—*Abstracted from Professor H. Neese's Paper, "Stahl und Eisen." Test of Lap Welds.*

No.	Analysis of Powder.	Result.	Microscopic Examination.
1	25 Carbon, $5Al_2O_3$, 20 glass, 20Ca O, $10B_2O_7$, $10SiO_2$, $10Na_2CO_3$	41 per cent. strength.	More blowholes, more slag inclusions, Nitride lines.
2	30 per cent. Ferro Silicon, 45 per cent. Si, 10 per cent. Ferro Manganese, 50 per cent. Mn, 15 cent. Si, 5 per cent. Mn, added to Flux I.	50-59 per cent. strength	As above.
3	35.5 Boric Acid, 50 NaCl, 27 Pot. Ferro Cyanide, 7.5 Rosin	61 per cent.	Blowholes, slag inclusion. Fewer nitride needles.
4	An American Flux, 10 Mg, 5Al, 5C, 25MgO, 25CaO, $25SiO_2$ $5Na_2CO_3$	55.9 per cent.	Free from large blowholes, numerous slag inclusions; structure comparatively free from acidularity.
5	40 Borax, 45 Glass, 15 Soda	57.7	No large holes, numerous small slag inclusions.
6	$35H_3BO_3$, 35CaO, 30C. Recommended as good by several sources.	63.3	No special features.
7	Aluminium and Magnesium added to 6 in same percentages as in No. 4.	Lower strength	Usual features.
8	No Flux	59.5 per cent.	

TABLE II.—*Tests of Butt Welds, abstracted from Professor H. Neese's Paper.*

Test No.	Flux.	Yield Point. Kg.	Ultimate Strength. Kg.	Ultimate Strength. Kg. (Per sq. mn.)	Ultimate Tons. Sq. Inch.	Extension. Per Cent.	Contraction in Area.	Strength in Per Cent. Original Bar.
1	None.	7900	10600	35.5	22.54	8	12	83.8
2	Powder	1.7050	11600	36.9	23.4	8.5	15	92.2
3	Powder	6.7340	11600	36.9	23.4	8.7	21	92.2

TABLE III.—*Tests of Welds made by the British Arc Welding Co. on ½-inch M.S. Plate.*

No.		Ultimate strength in tons per sq. in.	Extension per cent. in 8 ins.	Reductions of area per cent.	
1	Bare wire	25.4	26.1	56	Broke in solid.
2	Fluxed wire	25.7	20.2	51	,,
3	Fluxed wire	3.02	20.0	35	,,

Heat Treatment of Semi-Steel.

When repeating his lecture on semi-steel before the Lancashire Branch, Prof. Campion included the following section on heat treatment:—

Semi-steel appears to be more resistant to heat influences than ordinary cast iron, and therefore better suited for use in internal-combustion engine cylinders, liners, pistons, etc.

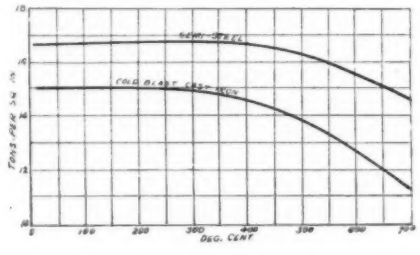


Fig. 1.—Tensile Strength of Two Samples of Cold Blast and Semi-Steel Cast Iron at Elevated Temperatures.

As is the case with cast iron, there is a marked loss of strength at temperatures above 500 deg. C., but for equal time of heating the rate of reduction is less. Castings, especially those of small section, are often annealed to remove internal strain or to render machining more easy at higher speeds. In many instances the loss of strength is too great in plain iron castings, but the use of semi-steel permits of sufficient annealing, and at the same time the retention of the desired strength in tension, transverse or impact.

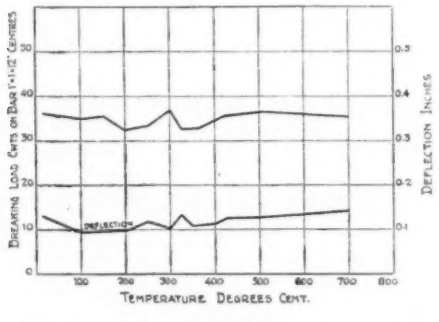


Fig. 2.—Transverse Strength of Semi-Steel at High Temperatures After Annealing.

Fig. 1 shows the effect of annealing at various temperatures for 6-hour periods on the tensile strength of semi-steel and a cold-blast iron mixture. It will be observed that the former not only retains its strength at higher temperatures than the latter, but that after the change point the metal deteriorates at a slower rate.

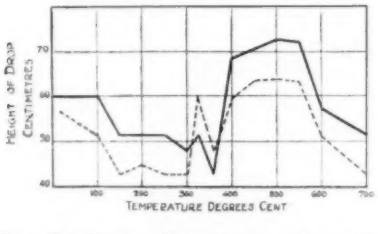


Fig. 3.—Impact Strength of Semi-Steel After Annealing.

The effect upon the transverse strength of the same semi-steel is shown in Fig. 2. The material undergoes very little change when annealed at temperatures up to 700 deg. C., but between 250 and 350 deg. C. it behaves erratically as regards both breaking load and flexibility. There appears to be some change which occurs in this region in all cast-iron materials, as transverse and impact tests, as well as tensile strength, whilst hot show discontinuity. The reason for such erratic behaviour has not yet been found.

The resistance to impact falls to about 250 deg. C., and rises steadily from 350 deg. C. to a maximum at about 550 deg. C., and then rapidly falls. In Fig. 3 the full line curve gives the results on the same semi-steel as referred to in Figs. 1 and 2, whilst the broken line curve shows the results of a similar material containing less manganese.

Fig. 4 shows the changes in tensile strength at various temperatures—that is, the material tested whilst hot and after being kept at the stated temperature for one hour, of the semi-steel (upper curve) and the cold-blast iron mixture (lower curve) of Fig. 1. The full lined curves represent the materials tested in the cast condition, and the broken line curves indicate the results obtained on the materials after submitting them to a four-hours' heating at 400 deg. C. and allowing to cool slowly, then heating to desired temperature for one hour and testing.

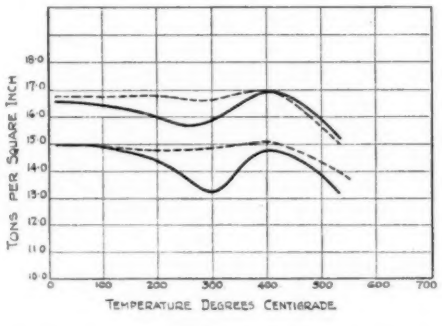


Fig. 4.—Tensile Strength of Semi-Steel and Cold Blast Iron at High Temperatures.

The results are greatly influenced by the time for which the specimens are maintained at the desired temperature before breaking. The longer the time the greater the loss of strength and the more steep is the curve.

The present Paper makes no pretence at dealing fully with the heat treatment of semi-steel or cast-iron materials, and it is not desirable that examples be multiplied, but what has been said will give a general indication of the effect of heat upon the metal.

In Diesel engine and similar work it is most important that the material should not undergo large changes in volume and shape on heating and cooling, and it is found that semi-steel is better than plain cast iron in this respect.

A New Zealand Exhibition.

An International Exhibition is to be held in Dunedin, New Zealand, opening about November 12, 1925. Though an Exhibition Company has been formed for convenience of organisation, the undertaking is being planned and supported on the widest basis. The New Zealand Government has given its patronage to the project, and is also assisting it financially. Though New Zealand is one of the youngest of the British Dominions, it has made great progress in less than a hundred years. Its people, numbering now, roughly, a million and a quarter, have striven with the conscious aim of building a New Britain under Southern skies, and it is wonderful what progress they have achieved. This will be their fourth International Exhibition. The first, held in Dunedin in 1865, was naturally restricted in its scope, but at the second, also held in Dunedin in 1889-90, half a dozen foreign countries, in addition to the United Kingdom and British Colonies, were represented. The third International Exhibition, held in Christchurch in 1906-7, was a great success, and it is to be expected that the new Exhibition, to be held two years hence in one of the fairest cities of what is certainly one of the most beautiful Dominions of the whole Empire, will surpass all previous records.

Institute of British Foundrymen.

COVENTRY BRANCH.

Discussion on Mr. H. Beeny's Paper on "The Influence of Composition and Rate of Cooling upon the Microstructure and Physical Properties of Cast Iron."*

MR. B. S. MORGAN (Rugby), referring to the last slide of burnt grey foundry iron, noticed that all the graphite was separated with ferrite right round it, and said he did not think it necessarily followed that the iron should be weak. Take wrought iron, for example, and its full content of slag.

MR. BEENY observed that the graphite flakes in the burnt grey iron were not similar in their arrangement to the slag found in wrought iron. In wrought iron there were cinder bands running parallel to one another in the direction of the rolling or forging, but in this case they would notice that the graphite flakes ran in all directions through the metal. In connection with wrought iron the effect of the slag-lines was well shown by subjecting a test-piece to impact stress. In a test-piece with slag lines running parallel to its length quite a high value was obtained, but if the test-piece was cut in the opposite direction, with the slag bands running in the reverse way, the result was a very much lower figure (owing to the weakness induced by the slag lines). The lecturer stated that the metal was comparatively strong so long as the cinder bands ran at right angles to the direction of the stress. In cast iron, where there were extremely large graphite flakes running in all directions and distributed in close formation, a crack would in the same way rapidly spread along them.

MR. MORGAN next referred to internal chill, and asked could the lecturer give any explanation of the cause and how to prevent it.

Inverse Chill.

MR. BEENY replied that he believed it would be generally agreed that internal chill occurred in irons low in manganese and high in sulphur. In such irons, instead of manganese sulphide there was ferrous sulphide.

MR. MORGAN next asked for an explanation of the difference obtained in certain castings. Out of several small castings from the same cupola the majority turned out grey, but some showed internal chill.

MR. BEENY stated that as a matter of fact so far as he knew there was no satisfactory explanation extant, though there were several theories or reasons put forward. One was the segregation of sulphur at certain points within the mass of metal. It was well known that sulphur had a whitening effect upon metal, and was supposed to prevent decomposition of the pearlitic carbide. So wherever there was this segregation of sulphur they were likely to find white patches, provided the balance of the other constituents of the metal was such as to give a metal sensitive to the influence of sulphur. Then there was the point of pressure. Graphite occupied more space than carbon existing as carbide; if they had a strong outer casing to the metal graphitisation proceeded up to the point when the very considerable pressure in the interior prevented its further formation.

Compression Theory.

MR. MORGAN remarked that he thought this was probably the real explanation, because whenever this internal chill occurred he found that the grey iron stopped sharply and the white iron then appeared. In this connection he inquired as to any possible reaction due to the moisture in the sand cooling the outside of the casting. The grey portion cooled fairly rapidly, but not enough to cause a chill, and the strength of the metal then formed prevented interior expansion and brought it to a white condition. Would the moisture content of sand have any influence in this direction?

MR. BEENY replied that the higher the moisture content in sand the greater would be the chilling effect, while the casing round the metal would, of course, form more rapidly. Where there was a plastic or semi-plastic outer casing expansion could occur, but this greater severity of chill on the outside formed a firmer casing, which would resist the pressure set up by the process of graphitisation, and could possibly be an explanation of internal chill. Internal chill was a subject which required special study before one could express a definite opinion.

Heat Treatment is Useless.

MR. C. SCAMPTON, touching on iron having an interior chill and the contrast in results quoted by Mr. Morgan—some castings quite good and a smaller number chilled—asked whether, if the temperature was brought to 900 deg. Centigrade and the metal allowed to cool, this process would bring the castings to the same composition or nature again.

MR. BEENY remarked that it had been found that some of this internal chilling was very persistent, and in such cases annealing treatment did not readily remove it. However, he could not speak with any special knowledge of the treatment mentioned by Mr. Scampton, though he should say that annealing in most cases would remove internal chill. Particularly where there was high sulphur in the iron the tendency was to obtain a white structure which was difficult to get rid of by heat treatment.

MR. MORGAN pointed out that in annealing the effect was that, instead of obtaining graphitic flakes, the graphite became nodular in form; the structure was mottled as distinct from the ordinary grey iron.

MR. BEENY agreed that this was so if they were dealing with malleable iron, but with ordinary foundry iron, which already possessed graphite flakes, the graphite would precipitate upon those flakes already formed. This had been demonstrated, and he himself had seen actual micro-specimens showing this action. He saw the structure before and after annealing, and in the first instance there were the primary graphite flakes, while after annealing there was no nodular graphite observable in the presence of these flakes, but simply larger primary graphite flakes.

MR. MORGAN stated that in the case of internal chill there were no graphitic flakes to grow upon, unless the growth was from the grey iron inwards.

MR. BEENY answered that it was true that they would certainly get a more or less spherical structure upon annealing where there were no graphite flakes upon which to precipitate. He thought this point had been conclusively shown by various people: that it was an important matter, if it was intended to anneal an iron, not to have primary graphite there, because any further decomposition which took place resulted in the growth of these flakes instead of the formation of secondary graphite, which, of course, was a much stronger form.

Black-Heart Steel.

A MEMBER said he had noticed that the slide showing the effect of annealing on high carbon steel with 1.26 per cent. carbon, while it showed that the cementite had been decomposed into nodules of graphite, the areas of pearlite appeared to be left. He wondered if there was any condition in cast iron which would make that reaction somewhat different. He remembered getting hold of a piece of cast iron which had been very severely chilled, and then tried to anneal it so as to leave a fair amount of combined carbon by adjusting the rate of cooling. When he examined the iron under the microscope he found that the pearlite had gone, and that the ferrite and graphite had actually replaced it, but there were still persisting in it some needles of the original cementite. Could the presence of other elements in a larger percentage have the effect of rendering the cementite comparatively more stable than the pearlite, thus resulting in the pearlite being removed before the cementite began?

MR. BEENY observed, referring to the graphitised steel, that it was probable that the graphite was formed within the pearlitic areas, but the graphitic structure itself would be formed, of course, at a temperature somewhere within the Austentitic range. At this temperature there would be a

* See last week's issue.

homogeneous solid solution of carbide in iron, and at some point within this homogeneous mass there developed a separation of graphite. He did not know the exact temperature at which the metal was annealed—and possibly there would be some cementite still remaining undissolved. He did not think that the cementite would break down directly to graphite, but thought the graphite would be formed as indicated above, and for this reason. He had examined an iron which was chilled and treated similarly to that which had been referred to, and he then noticed there was some massive cementite still remaining in contact with ferrite and graphite, even as in the case quoted. He interpreted this to be the result of the graphitisation which had occurred through the solid solution, the Austentite—that was, through the carbide actually in solid solution in the iron. The lecturer explained the process by a rough diagram, showing how the solid solution dissolved up carbide from the massive cementite which existed in the neighbourhood of the graphite. In this way they could see how graphitisation proceeded by means of the solid solution, which conveyed the carbide from the massive cementite to the graphite flakes, where it was decomposed; and as the carbide decomposed so more carbide entered into solid solution. If the annealing was stopped before all the carbide had disappeared, they could get graphite and also ferrite in contact with massive cementite.

At the close The President (Mr. C. Dicken, M.I.M.) said the lecture had been very instructive and interesting. It would give them something to think about, and no doubt provide them with something which was beneficial in their work.

LANCASHIRE BRANCH.

The annual general meeting of the members of the Lancashire Branch of the I.B.F. was held on Saturday, April 5, at the Manchester College of Technology, Mr. R. A. Miles presiding.

The Secretary, Mr. T. Makemson, stated that the annual meeting was being held in April, instead of in May as last year, in order to comply with the new Branch rules. Therefore the report he presented covered a period of eleven months.

The membership stood at 286, which compared with 262 last year. There were now 92 members, 179 associate members, 6 associates, and 9 subscribing firms. During the year 43 new members had been admitted and 19 names had been removed from the roll owing to resignations or other reasons. Subscriptions to the amount of £292 19s. had been received and forwarded to the General Office. From this the Branch received £75, which, with 9s. bank interest, represented the income for the year. The addition of the balance in hand, £18 18s., made a total of £94 5s., and the expenditure, including that in connection with the Burnley section, was £81 16s. 9d., leaving a balance in hand of £12 8s. 3d.

The syllabus of Papers had dealt with many sides of modern foundry practice, and on September 1 the members had the privilege of hearing a lecture by Dr. Moldenke. The usual attendance at the meetings was between 70 and 80. A propaganda meeting at Wigan in October was attended by 270, and a small increase of membership had resulted. It was anticipated that in course of time the Branch would substantially extend its membership in West Lancashire. Visits had been made to the works of Messrs. Musgrave & Company at Bolton, and of the Metropolitan-Vickers Electric Company at Trafford Park. On the latter occasion the visit was made in conjunction with the members of the American Foundrymen's Association, who had come over to attend the Conference at Paris. Official invitations to attend meetings of the Institution of Mechanical Engineers (North-Western Section), the Manchester Association of Engineers, and the Manchester Metallurgical Society had been accepted by the members, and in its turn the Branch had invited the members of those organisations to attend the meeting of the Branch on May 3.

The annual conference of the Institution was held in Manchester, and other events in which the members were concerned were the visit of the members of the American Foundrymen's Association and the International Conference at Paris. Mr. W. H. Sherburn, the first President of the Branch, had been awarded the Oliver Stubbs medal for his Paper on "The Evolution of the Foundryman." Diplomas had also been awarded to Messrs. Rawlinson and Rowe for Papers given before the Sheffield and Lancashire Branches, and to Mr. Bickerton and Mr. Masters for Papers given before the Burnley section.

Unfortunately, many members had suffered from the continued trade depression, but it was hoped that, with recovering trade, the next year's work would be even more successful than that of the past year.

The report was adopted. On the motion of Mr. J. Prescott, seconded by Mr. G. Ball, a vote of thanks was accorded to the retiring officers for the work they had done.

The following officers were elected for the next session:—President, R. A. Miles; Senior Vice-President, J. Masters; Junior Vice-President, S. G. Smith; Secretary, T. Makemson; Auditors, W. H. Grandison and R. P. Layfield; delegates to General Council, E. E. Grimwood, J. Hogg, A. L. Key, J. S. G Primrose, W. H. Sherburn. The three vacancies in the Council were filled up by the election of Messrs. J. Pell, A. Sutcliffe, and R. Stubbs.

Mr. Key raised the question of the times of meeting, stating that several members thought Saturday afternoon an inconvenient time.

Time of Meeting.

The Chairman remarked that the point had been mentioned on several occasions, but not at the right time. This being the annual general meeting, it was a suitable opportunity for members to bring forward any grievances they had or suggestions for improvement in any respect. His own opinion was that no change should be made. Some members came as far as 30 miles to attend the meetings, and Saturday was the most convenient day for them.

Mr. A. Hill: This is the Lancashire Branch, not the Manchester Branch, and we have to consider the members who come from outside.

Mr. Simkiss recommended Friday evening at 7 o'clock. Mr. Jolley expressed his willingness to support this, with a proviso that consideration be given to the question of holding meetings in other towns.

Mr. S. G. Smith suggested that notice should be given of an important question like this. It was unanimously agreed that the matter be included in the agenda at the next annual meeting.

Obituary.

Mr. Wm. F. MacNamara, proprietor of the Shannon Foundry & Engineering Works, Limerick, has died.

Mr. F. J. Cribb, Sand Rock House, Retford, died recently. He was chief engineer at Marshall, Sons & Company, Limited, Gainsborough.

Mr. James Martyn, who died on April 18 in London, was a prominent manufacturer of Melbourne, and was also managing director of the Steel Company of Australia.

Mr. J. Newlands, for many years London representative of the Farringdon Works and H. Pontifex & Sons, Limited, of 43, Shoe Lane, London, E.C.4, died recently in his 76th year.

Mr. Joseph Kidd died at his residence, Garibaldi Terrace, South Shields, on April 19. He was outside manager of Charles Rennoldson & Company, shipbuilders, for many years.

Mr. H. G. Austin, a representative of C. and J. Hampton, Limited, ironfounders and vice manufacturers, of Record Works, Ouse Road, Sheffield, died recently at Ashford, Middlesex.

Professor Grenville Cole, Professor of Geology at the Royal College of Science for Ireland and Director of the Geological Survey of Ireland, died last week at his residence at Carrickmines, co. Dublin, at the age of 64.

Mr. Frederick Mountford, of Broad Oak, Park Head, Sheffield, died recently, aged 78. He was the head of the firm of Frederick Mountford & Sons, Wellfield Works. This business was founded in 1820, at Totley Forge, by Mr. Mountford's father. The deceased was actively engaged in the business up till two years ago.

Liquid Steel for Light Castings.

By J. A. Holden.

In a recent Paper, in which reference was made to the manufacture of steel castings, the quality of steel made by two processes was briefly alluded to.* Mr. Harley stated: "The 'Stock' converter has given great satisfaction, producing metal of regular composition and ample fluidity for pouring light work." On the other hand the electric process—to quote his words—"has not been so successful in producing reliable and consistent metal, and the chief trouble is porosity."

Before suggesting the probable cause of the porosity the writer proposes to show that the "Stock" plant, in addition to turning out mild steel of good quality, can be adapted for making many types of special steels.

The process is essentially simple, and provided reasonable care is exercised it is not difficult to secure satisfactory metal. The charge is mainly pig-iron, and scrap, when used, rarely exceeds 12 per cent. Various brands of pig-iron are used, such as Thornaby, Weardale, Ulverston, etc. Some steel makers consider that pig-iron containing 1 per cent. of manganese is necessary, whilst others use brands with about 5 per cent.

The charge is melted in the converter with oil fuel, and the products of combustion are taken through economisers. When the charge is molten the blast pipes are introduced into the tuyere box at the side; the vessel is turned up, and the molten bath blown with the blast pre-heated by passing through the economisers. Thus "Stock" steel is of the Bessemer type, differing from the early process chiefly in the method of melting. If good hematite is used, since there is no contamination during melting, the resulting steel is very pure.

Typical Charges.

Details of two typical casts made with a 2-ton plant are appended below:—

1. *Steel Casting Heat.*

Charge :—Thornaby No. 2	42	cwts.
Mild steel scrap	2	,,
	44	cwts.
Finishing Alloys :—Silico Spiegel	81	lbs.
No. 1 Hematite	50	,,
Ferro Manganese	20	,,

Analysis :—C., 0.24; Mn., 0.52; Si., 0.28; S., 0.022; and P., 0.30 per cent.

2) *Medium Carbon Steel Castings.*

Charge :—Thornaby Pig. (Si., 2.1; and Mn., 1.5 per cent.)	31	cwts.
Mild steel scrap	4	,,
	35	cwts.
Finishing Alloys :—Silico spiegel	56	lbs.
Ferro-manganese	50	,,
Molten iron (crucible melted)	3	cwts.

Analysis :—C., 0.51; Si., 0.22; and Mn., 0.89 per cent.

The casting when normalised gave maximum stress 549 tons, and yield point 29 tons per sq. in., associated with an elongation of 10 per cent.

When it is desired to make alloy steels such as those containing nickel, ordinary blowing practice may be followed; but if there are large finishing additions a very hot bath may be required, and this is readily obtained by blowing a pig-iron richer in silicon. Nickel can be introduced and melted with the pig-iron. If this procedure is adopted the percentage addition is calculated upon the estimated weight of the blown bath, *i.e.*, there is no loss of nickel during blowing, but as there is loss of iron, etc., the nickel becomes concentrated. Usually an addition calculated upon 85 per cent. of the metals charged will yield the desired percentage. Ferro-chrome additions should be in the form of lumps heated to bright redness.

* "Metallurgical Control in Automobile Foundry Practice." A. Harley.

Particulars of two alloy steels are appended:—

Nickel-chrome Steel.

Charge :— Carnforth pig	40	cwts.
Scrap	3	,,
Nickel	140	lbs.
Finishing Alloys :— Spiegel	36	lbs.
Ferro-manganese	32	,,
Ferro-chrome C., 6.0 and Cr., 70.0 per cent.	71	,,

Analysis :—C., 0.31; Mn., 0.41; Ni., 3.3; Cr., 1.0 3 and Si., 1.0 per cent.

Manganese Steel.

Charge :—Thornaby, No. 2	44	cwts.
Scrap	2	,,
	46	cwts.
Finishing Alloys :—Spiegel	56	lbs.
Ferro-manganese		
Coke melted	820	lbs.

Analysis :—C., 1.32 and Mn., 12.8 per cent.

Thus with an auxiliary melting equipment the "Stock" plant can be made very adaptable. In many foundries this may not be necessary; on the other hand, if a foundry is regularly called upon to deal with special steels the "Stock" converter is quite suitable for many of these requirements.

The Field of the Electric Furnace.

The electric furnace, although not so economical for intermittent work, is likely to hold the field for the production of light castings. It requires more skilled supervision than a converter, and it also demands the undivided attention of the furnaceman. If the foundry foreman has been used to a converter plant it is often a difficult task to get him accustomed to a process which will not deliver a ladle of steel within an hour. The writer has observed that such men will regularly call for a ladle of steel for 2 p.m., and not be ready for it for several hours afterwards. This, however, is largely a matter of inexperience, and time provides the remedy.

Non-Co-operation.

Observations in many steel foundries convince the writer that there is, as a rule, little co-ordination between the steel-maker and the foundry-foreman. The *post-mortems* upon waster castings generally develop into very acrimonious discussions, and the steel maker, as a rule, earns nothing but wrathful contempt. The result of the argument is briefly as follows:—(1). The steel was "beastly" bad. (2). The mould was of the same order.

A few weeks ago it was innocently suggested that the designer would be the man to figure as the "Solomon" in these little matters. Under such circumstances the natural anticipation would be a third conclusion. (3). The design belongs to the same category as No. 1.

The Cause of Bad Electric Steel.

If a foundry is producing unsound castings it is unwise to condemn the steel-making process, for unless the process can be worked to produce sound steel it is hardly likely to develop, for example, to the extent that the electric furnace has done. In spite of many rigid specifications, composition has little bearing on the problem. As a result of observations on many plants the writer has found that the chief causes of unsoundness in electrically melted steel are:—(1) Improperly melted, over oxidised—either by very slow melting or by incorrect slag conditions; (2) casting before the steel is dead melted; and (3) occasionally unusual impurities in the scrap—particularly antimony and tin (from white metal).

To make satisfactory steel the process is controlled from the slags, and the temperature of the bath at the various stages is also of importance. The charge should be melted with the mini-

mum quantity of iron oxide; a melting-slag, rich in lime and containing not more than 20 per cent. of ferrous and ferric oxides with a silicon content of 10 per cent. may be taken to be representative of good melting practice. If the scrap is high in carbon, it is not advisable to attempt to decarburise with a watery slag. It is better to increase the melting voltage—on a three-phase furnace a line voltage of 110 is necessary. With this current the "boiling" proceeds more steadily. By careful observation the melter will know exactly what the slag requires. Charges high in carbon are accompanied by long, luminous flames around the electrodes, the slag rapidly changes in colour, becoming light brown; it may (if not dealt with) become white.

Catching the Carbon.

High carbon in the melting stage is not likely to occur in the steel foundry, since a proportion of the charge (such as runners, users, etc.) will always be mild steel. If, however, a consignment of high carbon scrap has to be dealt with it is often preferable to catch the carbon coming down. For instance, if the bath melts out with 0.60 per cent. carbon and a steel of 0.30 per cent. is required, it is not difficult to slag the charge at 0.35 per cent., and tap at 0.30 per cent. It is true the phosphorus content may not be down to 0.01 per cent., but for many castings 0.03 to 0.05 per cent. is permissible. A very sound steel can be more expeditiously obtained in this way than by decarburising to 0.10 per cent. and then deoxidising.

Quick Melting Advocated.

The quicker the charge can be melted the better—from every point of view. If a rapidly-melted charge can be quickly slagged and maintained hot it will lay the foundations of good steel making. For refining the writer has proved the efficacy of the carbide slag. In mild steels it is safer to add calcium carbide; for a 2-ton heat, 10 lbs. is sufficient. It should be added after the finishing slag has become almost white.

For mild steel castings, the silicon-content need not be more than 0.20 per cent.; if it should be much higher the steel will have a high shrinkage, and to prevent shrinkage cavities large feeders will be required. On more than one occasion the writer has been shown a so-called unsound steel which contained nothing but a shrinkage cavity.

Electric Steel has High Shrinkage.

Electrically-melted steel has a much higher shrinkage than steel made by other processes. It is therefore inadvisable to copy the compositions used by "Tropenas" and such like processes where silicons of 0.5 per cent. are not unusual.

Life of Electric Steel.

To cast very many boxes from one ladle of steel with electric steel is to some foundrymen a feat rarely accomplished. This, however, should be an every-day occurrence in a well-organised shop. With the casting floor properly set out, an expert crane driver and a capable ladle-man the steel maker should not find it difficult to pour 100 to 200 boxes from 2 tons of steel. If the steel is thoroughly deoxidised and cast with a thick slag covering it has plenty of "life." For very light castings, the writer advocates an addition of dolomite to the slag a few minutes before tapping. By this means the freezing point is raised, and the slag forms a solid crust over the ladle top which has excellent heat-insulating properties.

Very hot steel is advantageous, and providing it can be handled there is no objection to its use. To save the stopper-end the ladle will require careful manipulation; in fact the stream should not be fully shut off until the steel becomes visibly cooler. It is not necessary to cast with a running stopper, but a gentle dribble will prevent the stopper end from sticking, and it will also enable the crane driver to sight the runners. Heavy sleeves and a stout stopper end are indispensable, and the made-up sleeve should be air-dried for several days before setting in the ladle. It is impossible to secure satisfactory results unless a very efficient ladle-man is available. The writer has found that it is, as a rule, not difficult to train a good ladle-man from the general labourers in the foundry. Selecting a man who has shown adaptability, alert and cool under trying conditions, such as, for example, with a running stopper, and allowing him a week or so with the crane driver to realise the co-ordination necessary between them, and also to view the whole casting operation and realise the demands made on the ladle-man, he will then be ready to commence as a ladle helper, and finally become capable of doing the entire work himself.

The Acid Electric Process.

Although not developed to any extent in this country, there is a field for the acid-lined electric furnace. The difficulty is to secure a source of reliable scrap containing not more than 0.04 per cent. of sulphur and phosphorus. The process is very simple, being much on the lines of the acid open-hearth. The steel becomes automatically dead melted because of the silicon reduced by the arcs from the slag. There is, of course, no "slagging off," as in basic practice. Sand and lime, together with a little iron ore, are used to form the slag. If necessary more ironstone is added. When the carbon is nearly down to the required limit, if the iron-ore additions have been cautiously made the slag becomes glassy and very pale green in colour. The writer has found that the acid steel pours well and gives very clean castings.

Personal.

We regret that in announcing the death of Mr. Morehead in our last issue the initials were given as J. S. instead of C.

Mr. T. R. Shaw, works manager for Horsfall & Bickham, Limited, Orchard Street, Manchester, has resigned his position to join the staff of the Churchill Machine Tool Company, Limited, Broadheath, Manchester.

Mr. B. P. Deane has been appointed to succeed Mr. A. K. Rhoden as manager for London and the Home Counties, of Sanderson Brothers & Newbould, Limited. The latter gentleman is to take charge of the firm's overseas business.

Wills.

Hamilton, E., manager of the River Bolt and Nut Company, Limited, Gateshead	£5,978
Wenham, A., a director of the Steel Pipe Company, Limited	£22,070
Coulter, S., of Broad View, Arnside, Westmorland, iron and steel merchant, late of Heckmondwike, Yorks	£7,645
Dixon, R. E., chairman of S. Dixon & Sons, Limited, brass founders, Swinegate, Leeds	£9,347
Bullough, A. E., senior partner in the firm of John Bullough, Collier Brook Bolt Works, Atherton	£32,251
Preston, H. J., managing director of the Kettering Iron & Coal Company, Limited	£25,275.
Beckwith, S., commercial manager of the Glasgow Iron & Steel Company, Limited	£2,888.
Hope, J., of the Knoll, Lenzie, Dumbartonshire, late manager of the Nickel Company's works, Kirkintilloch ...	£4,320.
Drake, D., a director of James Mackrell & Company, Limited, Union Foundry, Elland, Yorks.	£1,810

A conference was held at York on April 16 between officials of the National Union of General Workers and the steel employers respecting an application for an increase of 10s. per week on existing rates. This application follows notice terminating the sliding scale.

The shipyards and plant of the Forth Shipbuilding Company, Limited, Alloa, were offered for sale by auction on Wednesday in the Faculty Hall, Glasgow, at an upset price of £30,000. The ground extends to 13 acres, and there are seven building berths for vessels up to 500 ft. long. There were no offers, and the sale was therefore adjourned.

Macfarlane & Robinson, Limited, have concluded an agreement with Joseph Sankey & Sons, Limited, enamellers and stampers, Bilston. In brief, it means an exchange of the resources of that firm, in the way of black stampings, in return for placing the enamelling facilities of Bushbury at the disposal of Macfarlane & Robinson, Limited.

MACNAB & CO.

Tabor Patent Portable Combination "Shockless" Jarring Roll-over and Pattern-Drawing

MOULDING MACHINE.

British Built.

Box and Mould—after being Rammed—in position of being Rolled over.

Special Features and Advantages.

Sand jar rammed by "Shockless" device—Tabor Patent—without shock to the machine or surrounding moulds.

*** Machine not restricted to use of one size moulding box—any size can be used up to load capacity of machine.**

Good surface castings.

Pattern plates can be changed instantly without unfastening mechanism so that comparatively small quantities can be made economically.

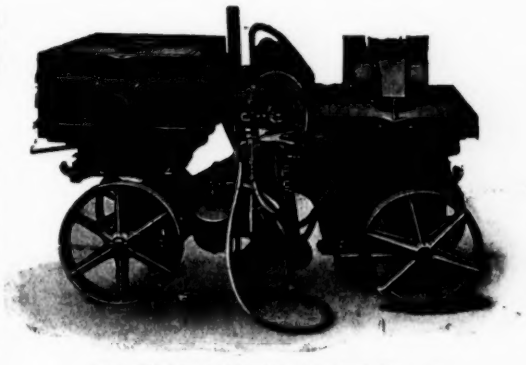
Perfectly straight draw ensured by mechanical guides of large surface to prevent wear and retain accuracy.

All moulds jar rammed in a few seconds and thoroughly uniform in density, ensuring minimum quantity of defective castings and less blow holes.

"All operations other than sand filling are completed in two minutes for any size of work within capacity of machine. To realise what this means, compare your present wage cost for the same work!"

CAPACITY.

SIZE	* Size of Moulding Box.	Straight Pattern Draft.	Nett Weight of load that can be rolled over at 80lbs. pressure.
18	18 in. wide. 36 in. long. 12 in. deep.	8 in.	450 lbs.
24	24 in. wide. 48 in. long. 15 in. deep.	10 in.	800 lbs.



The Finished Mould—showing Pattern after being drawn.

We make various models and sizes for all types of machine moulding, according to class of work and numbers.

SEND US DRAWINGS OF YOUR WORK FOR SPECIFIC EXPERT ADVICE, ... ACCORDING TO YOUR CONDITIONS AND QUANTITIES. .. ..

56/8, EAGLE ST., SOUTHAMPTON ROW, LONDON, W.C.1.

WORKS
TOTTENHAM, LONDON, N.17

Code: Western Union.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—With the resumption of business after the holiday suspension, makers of Cleveland iron are adopting a somewhat firmer attitude with regard to prices, due, it may be assumed, to a revival of activity in the export section of the trade, shipments of pig-iron for April, already ascertained, having increased in tonnage to the extent of about 75 per cent. as compared with the figures of the previous month. Quotations this week have been lowered, and are at 92s. for No. 3 G.M.B., and a reasonable, practicable level having been reached, a good, active business should proceed on this basis. Of course, a pretty large volume of business was done at 90s., and home consumers are, for the time being, fairly well covered. But buyers with purchases still to complete would probably find it to be no advantage to wait, for there is certainly nothing in the present situation to indicate any further fall in values. The further improvement in the franc strengthens the export outlook, though trade with Germany is hampered by the difficulty experienced by buyers in that country in obtaining foreign drafts. Prices current are as follow:—No. 1, 97s. 6d.; No. 3 G.M.B., 92s.; No. 4 foundry, 91s.; and No. 4 forge, 90s. per ton.

There is a fair, steady business passing in hematite on Tees-side, and although the holidays have somewhat interrupted business, the rather better labour outlook points to a much-needed expansion of trade in the immediate future. Meanwhile, East Coast mixed numbers are quoted round 99s., with 1s. per ton more for the No. 1 quality. In West Cumberland and North Lancashire reports indicate that at the moment the output of the eight furnaces in blast is being absorbed, and that heavy stocks are not accumulating in the works' yards. Bessemer mixed numbers are quoted at 110s. per ton delivered at Glasgow and Sheffield, and 117s. 6d. per ton at Birmingham.

MANCHESTER.—Movements in the local pig-iron markets continue uneventful, the majority of consumers having completed purchases to cover requirements over the holiday season, and very few new orders being placed in the meantime. Midland furnaces do not seem at all anxious to take orders here, although they are still willing to sell No. 3 on a basis of 95s. per ton at the furnaces. The lower prices accepted by some of the Cleveland makers make it possible for Cleveland No. 3 to compete with Derbyshire in Lancashire consuming districts up in the North, and, perhaps, as far down as Blackburn. This, of course, restricts the selling scope of Derbyshire iron, but there is at present no pressure to sell the latter, and hence the competition of Cleveland, so long as it does not reach Manchester, is of little consequence.

THE MIDLANDS.—Conditions in the foundry pig-iron industry have developed a firmer tendency in this area, and a more active buying movement is anticipated with the resumption of work after the holiday recess. It now appears that the founders can see no further advantage in waiting, as it is most unlikely that there will be any drop in price for the next few months. It is possible now to obtain quite freely Nos. 1 and 3 grades of foundry iron, as most of the furnaces have these grades in stock. There has been considerable tonnage of South Staffs. iron sold in the Black Country at a price which gives two or three shillings advantage over the Derbyshire and Northants prices, which is accounted for by the smaller railway rate. The current prices are as indicated below:—Derbyshire No. 3 foundry, 95s.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 92s. 6d.

SCOTLAND.—Reports from the various centres of industry continue disappointing, with very little buying in progress. Prices meantime remain steady at last week's level, viz., 100s. for No. 3, f.o.t. furnaces. The price of No. 3 Middlesbrough, f.o.t. Falkirk, is 100s. per ton; whilst No. 4 foundry is quoted at from 1s. 6d. to 2s. per ton less.

Finished Iron.

As far as crown bars are concerned, consumers seem to be rather chary about paying the new basis of £13, but really there has not been enough experience yet to test the strength of the quotations, the past two meetings having been entirely holiday ones. From makers' point of view, there is full justification for the recent advance in marked bars in the very high cost of production, but the demand for such iron is so small in comparison with the capacity to produce it that some people profess to regard the retention of the new basis as extremely problematical. Some firms find it difficult to keep even half their plant in operation, and that is not a condition which promotes strength of quotations. The marked bar price will be maintained, of course, even though some of the makers have not much work booked. Common iron at £12 is not a very attractive proposition to the consumer, but as the very limited demand now left to British makers will not be much affected either way, the quotation does not seem to matter very much. Quotations:—Marked bars, £15 (net f.o.t. makers' works); crown bars, £13; common bars, £12; gas strip, £13 5s.; all net delivered Birmingham area.

Steel.

The recent improvement in foreign exchanges has had a somewhat favourable effect upon the outlook for home steel producers, with the result that the demand for billets is stated to be on the increase now the Continental competition is no longer active. With very little, if any, difference in the price of basic billets, whether home or Continental, users know perfectly well that the former are to be preferred, and as no early drop in Belgian and French quotations is anticipated the next few weeks should see a distinct improvement in the demand for British material. Acid billets are a fair market, but producers are not by any means "all out." While tool steel is being bought on a big scale, crucible and the best high-speed steels are very slack. In the market for alloys a steady business continues in ferro-manganese, but all for small parcels, the export business being on a par with the home trade in this respect. Similar conditions prevail in the United States, where only small tonnages are sold. The price for both the English and domestic article is $107.50, equivalent to £24 11s. 3d. at the current rate of exchange. The quiet state of the tinplate market, of course, has been largely due to an unsettled feeling owing to the continuous fall in the price of block tin, and works are disposed at the moment to accept slightly lower values, especially as there is an absence of substantial business passing. The Continent, and also India, have taken fair quantities at 24s. 3d. to 24s. 6d., basis, I.C. f.o.b. works' port.

Scrap.

The position in the scrap metal trade continues unsatisfactory, both sellers and buyers having practically suspended active business until conditions assume a more settled appearance. Apparently the scrap trade in Lancashire is bearing more than its fair share of the effects of depression. There is too much of it about, and until the consumptive demand is much larger, it cannot be expected that fair values will be paid. Foundry scrap is steady, and, as a rule, Lancashire dealers ask 90s. for broken machinery metal delivered to the consumer, but occasionally weak sellers will accept 87s. 6d. per ton. There is, of course, considerably more of this class of scrap available than can be absorbed in the present state of the foundry industry, and there is no sign yet that foundrymen are becoming any busier. In Scotland supplies of scrap are still none too plentiful, but prices remain practically unchanged. Heavy machinery cast-iron scrap is slow to move, and changed hands this week at 95s. and 97s. 6d. per ton, with ordinary cast iron in handy pieces 3s. 6d. to 5s. per ton less. Old cast-iron chairs are 95s. to 96s. 3d. per ton, but consumers are not prepared to buy large quantities until they can see some signs of fresh orders. Ironworks cast iron is 90s. to 92s. 6d. per ton, and large pieces suitable for steelworks around 85s. to 87s. 6d. per ton. Light cast-iron scrap is 77s. 6d. to 80s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Movements in the standard copper market during the past week, for obvious reasons, have been without outstanding features of interest, and fluctuations in values have been confined within narrow compass. The general outlook for copper on this side of the Atlantic is by no means regarded as unfavourable at the moment, as Continental interest is likely to broaden further. The American exports for February totalled 35,630 tons. Of this total 11,290 tons were for the U.K., as against 5,680 tons for Germany, while 3,450 tons went to France, 3,196 to Italy, and 2,315 tons to Belgium. China took as much as 5,475 tons and Japan 1,050 tons. Germany appears likely to become a more important factor again, and the general absorbing capacity of Europe seems more promising. Current quotations:—*Cash:* Thursday, £64 2s. 6d.;

COLTNESS IRON CO., LTD.

Makers of the well-known and old-established

"COLTNESS" BRAND OF HIGH CLASS SCOTCH PIG IRON

FOUNDRY. No. 1, No. 3, No. 4.	**STANDARD GRADES**	HEMATITE. No. 1, No. 3, No. 4.

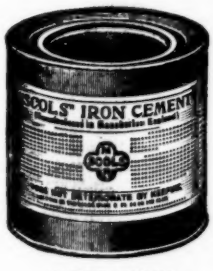
Works:— Newmains, Lanarkshire.

PRICES, ANALYSES, ETC., MAY BE OBTAINED ON APPLICATION TO THE GLASGOW OFFICE.

Office: 138, West George St., Glasgow.

THE WORLD'S BEST "IRON" CEMENT

MADE IN ENGLAND.



LISTS FREE.

Enquiries invited.

For Shipbuilders, Dry Dock Co.'s, Ironfounders, Engineers, Machinists, &c.

'SCOLS' SPECIAL IRON CEMENT *is a good thing*

ABSOLUTELY THE BEST—NOTHING BETTER MADE. **In Air-tight Lever Lid Tins.**

We also make "SCOLS" STEEL CEMENT.

Sole Manufacturers:

MAJOR, ROBINSON & CO., LTD.

'Scols' Works, Sykes Street, Chester Road, MANCHESTER

Telephone: 21, Penistone. **Telegrams: "Durranns, Penistone."**

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

Friday, £63 12s. 6d.; Monday, £63 12s. 6d.; Tuesday, £63 12s. 6d.; Wednesday, £63 5s. *Three Months:* Thursday, £65; Friday, £64 10s.; Monday, £64 10s.; Tuesday, £64 10s.; Wednesday, £64 2s. 6d.

Tin.—Quotations for standard tin during the past fortnight have consistently weakened, and at the week-end declined to about the lowest figure touched since the collapse of the recent boom. The rather less optimistic reports received from the United States during the past few weeks may, of course, be advanced as a possible reason for the weaker tendency of the tin market, but it is open to doubt whether it nas really been regarded as a serious factor. American consumption continues at a good average, and even if industry does slacken somewhat as the year passes, it is as likely as not that the tin-consuming plants may not be affected to any serious extent beyond a seasonal slowing down in the summer months. Current quotations:—*Cash*: Thursday, £246; Friday, £240 5s.; Monday, £243 15s.; Tuesday, £240 15s.; Wednesday, £236 10s. *Three Months:* Thursday, £245 15s.; Friday, £240; Monday, £243 12s. 6d.; Tuesday, £240 15s.; Wednesday, £236.

Spelter.—Values of this metal are now showing a firmer tendency, and inquiries are also in better volume. Supplies are now more plentiful, imports of refined and g.o.b. spelter into the United Kingdom during March totalling 12,010 tons, which compares with 9,028 tons in February and 7,420 tons in January. The market in America has shown an easier tendency, due to free selling and a slackening of the demand from actual consumers. Current quotations:—*Ordinary*: Thursday, £32 12s. 6d.; Friday, £32; Monday, £31 15s.; Tuesday, £31; Wednesday, £30 15s.

Lead.—The market for soft foreign pig continues firm with values steady on the whole. Prompt metal is still tight and the backwardation remains wide. It remains to be seen whether the anticipated increase in supplies expected during the summer will materialise and cause the quotations to approximate more closely. The position is largely dependent upon American consumption and its consequent effect upon the disposal of Mexican production. Current quotations:—*Soft foreign (prompt)*: Thursday, £32 7s. 6d.; Friday, £30 15s.; Monday, £31 15s.; Tuesday, £32; Wednesday, £31 15s.

Trade Talk.

The Alexandra Engineering Works, Limited, are being voluntarily wound up.

Middleton & Munro, electrical contractors, 59½, Clyde Place, Glasgow, are giving up business.

A fire at the Sheepbridge Works, near Chesterfield, caused considerable damage, the pattern stores being gutted.

The tender of the North British Locomotive Company, Limited, for ten locomotives for Western Australia, has been accepted.

Charles Yates & Company, Limited, iron and metal merchants, have removed from Billiter House, Billiter Street, to 26, Great St. Helens, London, E.C.3.

A contract for 40 passenger engines has just been placed by the East Indian Railway Company with the Vulcan Foundry, Limited, of Newton-le-Willows, Lancashire.

The business of William Hamilton & Sons, 93, West George Street, Glasgow, has been converted into a private limited liability company under the style of William Hamilton & Sons, Limited.

Mr. R. E. Williams, of 16, Russell Avenue, Bedford, has been appointed representative in the South Midlands and the Eastern Counties for George H. Alexander Machinery Company, Limited, machine tool agents, Coleshill Street, Birmingham.

The steamship "Brejwyk" arrived at Port Talbot on Monday morning, April 14, and commenced discharging iron ore at nine o'clock for Baldwins, Limited. The whole cargo of 2,073 tons was discharged by 5.45 p.m. the following day—a typical instance of quick despatch by the Great Western Railway Company at the port.

Rumours have been circulated to the effect that an amalgamation is being effected of the businesses of Vivian & Sons, Limited, Hafod Copper Works, near Swansea, and Williams, Foster & Company, and Pascoe, Grenfell & Sons, Limited, Morfa Copper Works, Landore, near Swansea.

Aluminium Casting.—In the centre of the Industrial Section of the British Empire Gas Exhibit at Wembley will be found a very interesting installation of crucible furnaces for the melting of aluminium. Small aluminium castings will be made from the metal melted in the furnaces, and sold as souvenirs to interested visitors. Aluminium castings are in great and growing demand in motor-car manufacture, in the making of wireless apparatus, in the construction of submarine engines, and in other industries where lightness of metal is an essential.

Company News.

Hales Pneumatic Jack and Pump Company, Limited, 36, Victoria Street, London, S.W.1.—Capital £5,000. Director: W. H. Walton.

Babcock & Wilcox, Limited.—Final dividend, 5 per cent., free of tax, together with bonus of 2 per cent., making 12 per cent., free of tax.

Statex Belting and Packing Company, Limited, Porter Street, Sheffield.—Capital £1,500. Directors: S. Baines, A. V. Goddard, J. Wright and F. Frolich.

A. D. Keeling & Company, Limited, Warstone Metal Works, Hall Street, Birmingham.—Capital £15,000. Manufacturers of and dealers in new and old metals, etc.

Reay Brass Foundry Company, Limited, The Eagle Works, Skinner Street, Stockton.—Capital £5,000 in £1 shares. Directors: J. Reay, J. K. Reay and J. L. Reay.

Richards & Yardley, Limited, 40, Weaman Street, Birmingham.—Capital £1,000. Brassfounders and engineers, etc. Directors: T. B. Fletcher and E. W. Yardley.

Sedgwicks, Limited, 36, West Ferry Road, London, E.—Capital £8,000 in £1 shares (1,500 10 per cent. cumulative preference). Mechanical engineers, metal workers, etc.

F. Reddaway & Company, Limited.—Dividend, 6 per cent. actual, for 1923, on preference shares, but nothing on ordinary shares; depreciation, £8,745; carried forward, £45,849.

Robinson Crane & Hoist Company, Limited, Providence Works, John Street, Carters Green, West Bromwich.—Capital £4,000 (500 A and 3,500 B). Directors: S. A. Hill and A. F. Lane.

Timmis & Company, Limited, Stamber Mill, Stourbridge.—Capital £35,000 in 6,000 5½ per cent. non-cumulative preferred and 29,000 ordinary shares of £1. Fire brick manufacturers.

Mansfield Gibson, Limited, 82, Pilgrim Street, Newcastle.—Capital £3,000 in £1 shares. Engineers, iron and brass founders, tool makers, etc. Directors: W. J. Watson, Mary Watson and J. G. Graham.

William Davy & Son, Limited, Lower Rake Head Mill, 11, Back Moorfield Street, Burnley. — Capital £1,500. Tinplate, zinc, iron and metal merchants, etc. Directors: W. Davy and T. C. Davy.

Cockin Brothers, Limited, Perseverance Mills, Brighouse, Yorks.—Capital £4,000. Steam and hydraulic packing manufacturers, etc. Provisional directors: J. Wood, H. A. Close, R. Morrell and F. Radcliffe.

Sanderson Brothers & Newbould, Limited.—Profit, £17,558; debenture and other interests, £7,809; debit balance brought forward, £1,131; arrears of preference dividend up to June 30, 1923; carry forward, £6,370.

C. F. Palmer (London), Limited, 403-5, Brixton Road, London, S.W.—Capital £5,000 in 4,500 preference and 500 ordinary shares of £1. Engineers, etc. Directors: C. F. Palmer (governing) and B. F. Palmer.

Hadfields, Limited.—Dividend, 4 per cent., less tax, on ordinary; profit, £106,510; brought forward, £128,418; interest on mortgage debenture stock, £57,605; preference dividend, £13,500; carried forward, £106,634.

Scunthorpe Silica Brick Company, Limited.—Capital £10,000 in £1 shares. Directors: J. G. Clugston, A. Watson, H. Watson, A. Thompson, W. Watson, T. H. Bibby and J. L. Brook. Solicitor: R. A. C. Symes, Scunthorpe.

E. T. White & Company, Limited.—Capital £15,000 in £1 shares (7,500 10 per cent. non-cumulative preferred ordinary). Engineers, agents for, manufacturers of engines and parts, etc. Directors: E. T. White (chairman and managing), E. H. Bolton, J. C. McClure and J. W. L. Kemp, 46, Leadenhall Street, London, E.C.

Metal Traders Technical, Limited.—Capital £150,000, to exploit technical and other kinds of processes, etc., concerning the technical improvement of any industry; advisory and consulting engineers in respect of mines, metallurgical and other works. Solicitors: Parker, Garrett & Company, St. Michael's Rectory, Cornhill, London, E.C.

Gazette.

Mr. Justice Eve has made an order to wind up compulsorily W. S. Laycock, Limited, of Millhouses, Sheffield.

The public examination of Mr. A. S. John, 1, Vaughan Street, Llanelly, and the Links, Pembrey, metal merchant, has been fixed for April 29 at the Guildhall, Carmarthen.

The discharge from bankruptcy of Mr. C. W. Forbes, who traded as the Tower Ship Repairing and Engineering Company, Tower Bridge Road, E., has been suspended for two years.